# Mentor® Verification IP Altera® Edition AMBA AXI3™/AXI4™ User Guide

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**Contractor/manufacturer is**:
Mentor Graphics Corporation
8005 S.W. Boeckman Road, Wilsonville, Oregon 97070-7777.
Telephone: 503.685.7000
Toll-Free Telephone: 800.592.2210
Website: www.mentor.com
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# Table of Contents


**Preface** . . . . . 1

About This User Guide . . . . . 1
AMBA AXI Protocol Specification . . . . . 1
Protocol Restrictions . . . . . 1
BFM Dependencies Between Handshake Signals . . . . . 1
AXI3 BFM Write Data Interleaving . . . . . 2
BFM Read Data Interleaving . . . . . 2
Supported Simulators . . . . . 2
Simulator GCC Requirements . . . . . 3
AXI3 and AXI4 Syntax References . . . . . 4

**Chapter 1**
**Mentor VIP Altera Edition** . . . . . 5

Advantages of Using BFMs and Monitors . . . . . 5
Implementation of BFMs . . . . . 5
SystemVerilog API Overview . . . . . 6
Configuration . . . . . 7
Creating Transactions . . . . . 7
Transaction Record . . . . . 8
create*_transaction() . . . . . 14
Executing Transactions . . . . . 14
execute_transaction(), execute*_burst(), execute*_phase() . . . . . 14
Waiting Events . . . . . 15
wait_on() . . . . . 15
get*_transaction(), get*_burst(), get*_phase(), get*_cycle() . . . . . 15
Access Transaction Record . . . . . 16
set*() . . . . . 16
get*() . . . . . 16
Operational Transaction Fields . . . . . 17
Automatic Generation of Byte Lane Strobes . . . . . 17
Operation Mode . . . . . 18
Channel Handshake Delay . . . . . 19
AXI3 BFM Delay Mode . . . . . 22
Data Beat Done . . . . . 23
Transaction Done . . . . . 23

**Chapter 2**
**The AXI Transaction** . . . . . 25

What is a Transaction? . . . . . 25
An AXI Transaction . . . . . 26
AXI Write Transaction Master and Slave Roles . . . . . 26
AXI Read Transaction Master and Slave Roles . . . . . 29

**Chapter 3**
**SystemVerilog AXI3 and AXI4 Master BFMs . . . . . 31**

Master BFM Protocol Support . . . . . 31
Master Timing and Events . . . . . 31
Master BFM Configuration . . . . . 32
Master Assertions . . . . . 35
AXI3 Assertion Configuration . . . . . 36
AXI4 Assertion Configuration . . . . . 37
SystemVerilog Master API . . . . . 37
set_config() . . . . . 38
get_config() . . . . . 40
create_write_transaction() . . . . . 41
create_read_transaction() . . . . . 44
execute_transaction() . . . . . 46
execute_write_addr_phase() . . . . . 48
execute_read_addr_phase() . . . . . 49
execute_write_data_burst() . . . . . 50
execute_write_data_phase() . . . . . 51
get_read_data_burst() . . . . . 53
get_read_data_phase() . . . . . 54
get_write_response_phase() . . . . . 56
get_read_addr_ready() . . . . . 57
get_read_data_cycle() . . . . . 58
get_write_addr_ready() . . . . . 59
get_write_data_ready() . . . . . 60
get_write_response_cycle() . . . . . 61
execute_read_data_ready() . . . . . 62
execute_write_resp_ready() . . . . . 63
wait_on() . . . . . 64

**Chapter 4**
**SystemVerilog AXI3 and AXI4 Slave BFMs . . . . . 65**

Slave BFM Protocol Support . . . . . 65
Slave Timing and Events . . . . . 65
Slave BFM Configuration . . . . . 66
Slave Assertions . . . . . 69
AXI3 Assertion Configuration . . . . . 70
AXI4 Assertion Configuration . . . . . 71
SystemVerilog Slave API . . . . . 71
set_config() . . . . . 72
get_config() . . . . . 74
create_slave_transaction() . . . . . 75
execute_read_data_burst() . . . . . 78
execute_read_data_phase() . . . . . 79
execute_write_response_phase() . . . . . 81
get_write_addr_phase() . . . . . 82
get_read_addr_phase() . . . . . 83
get_write_data_phase() . . . . . 84

get_write_data_burst() . . . 86
get_read_addr_cycle() . . . 87
execute_read_addr_ready() . . . 88
get_read_data_ready() . . . 89
get_write_addr_cycle() . . . 90
execute_write_addr_ready() . . . 91
get_write_data_cycle() . . . 92
execute_write_data_ready() . . . 93
get_write_resp_ready() . . . 94
wait_on() . . . 95
Helper Functions . . . 96
get_write_addr_data() . . . 96
get_read_addr() . . . 97
set_read_data() . . . 98

**Chapter 5**
**SystemVerilog AXI3 and AXI4 Monitor BFMs . . . 99**

Inline Monitor Connection . . . 99
Monitor BFM Protocol Support . . . 100
Monitor Timing and Events . . . 100
Monitor BFM Configuration . . . 100
Monitor Assertions . . . 104
AXI3 Assertion Configuration . . . 104
AXI4 Assertion Configuration . . . 105
SystemVerilog Monitor API . . . 105
set_config() . . . 106
get_config() . . . 107
create_monitor_transaction() . . . 108
get_rw_transaction() . . . 111
get_write_addr_phase() . . . 112
get_read_addr_phase() . . . 113
get_read_data_phase() . . . 114
get_read_data_burst() . . . 116
get_write_data_phase() . . . 117
get_write_data_burst() . . . 119
get_write_response_phase . . . 120
get_read_addr_ready() . . . 121
get_read_data_ready() . . . 122
get_write_addr_ready() . . . 123
get_write_data_ready() . . . 124
get_write_resp_ready() . . . 125
wait_on() . . . 126
Helper Functions . . . 127
get_write_addr_data() . . . 127
get_read_addr() . . . 128
set_read_data() . . . 129

**Chapter 6**
**SystemVerilog Tutorials . . . . . 131**
Verifying a Slave DUT . . . . . 131
AXI3 BFM Master Test Program . . . . . 132
AXI4 BFM Master Test Program . . . . . 134
Verifying a Master DUT . . . . . 142
AXI3 BFM Slave Test Program . . . . . 143
AXI4 BFM Slave Test Program . . . . . 153

**Chapter 7**
**VHDL API Overview . . . . . 167**
Configuration . . . . . 169
Creating Transactions . . . . . 170
Transaction Record . . . . . 170
create*_transaction() . . . . . 177
Executing Transactions . . . . . 177
execute_transaction(), execute*_burst(), execute*_phase() . . . . . 178
Waiting Events . . . . . 178
wait_on() . . . . . 178
get*_transaction(), get*_burst(), get*_phase(), get*_cycle() . . . . . 179
Access Transaction Record . . . . . 179
set*() . . . . . 179
get*() . . . . . 180
Operational Transaction Fields . . . . . 180
Automatic Correction of Byte Lane Strobes . . . . . 180
Operation Mode . . . . . 182
Channel Handshake Delay . . . . . 182
AXI3 BFM Delay Mode . . . . . 185
Data Beat Done . . . . . 186
Transaction Done . . . . . 186

**Chapter 8**
**VHDL AXI3 and AXI4 Master BFMs . . . . . 187**
Overloaded Procedure Common Arguments . . . . . 187
Master BFM Protocol Support . . . . . 188
Master Timing and Events . . . . . 188
Master BFM Configuration . . . . . 188
Master Assertions . . . . . 191
AXI3 Assertion Configuration . . . . . 191
AXI4 Assertion Configuration . . . . . 192
VHDL Master API . . . . . 193
set_config() . . . . . 193
get_config() . . . . . 195
create_write_transaction() . . . . . 197
create_read_transaction() . . . . . 201
set_addr() . . . . . 204
get_addr() . . . . . 206
set_size() . . . . . 208

get_size() . . . 210
set_burst() . . . 212
get_burst() . . . 214
set_lock() . . . 216
get_lock() . . . 218
set_cache() . . . 220
get_cache() . . . 222
set_prot() . . . 224
get_prot() . . . 226
set_id() . . . 228
get_id() . . . 230
set_burst_length() . . . 232
get_burst_length() . . . 234
set_data_words() . . . 236
get_data_words() . . . 238
set_write_strobes() . . . 240
get_write_strobes() . . . 242
set_resp() . . . 244
get_resp() . . . 245
set_addr_user() . . . 247
get_addr_user() . . . 249
set_read_or_write() . . . 251
get_read_or_write() . . . 252
set_gen_write_strobes() . . . 254
get_gen_write_strobes() . . . 256
set_operation_mode() . . . 258
get_operation_mode() . . . 260
set_delay_mode() . . . 262
get_delay_mode() . . . 263
set_write_data_mode() . . . 265
get_write_data_mode() . . . 267
set_address_valid_delay() . . . 269
get_address_valid_delay() . . . 271
set_address_ready_delay() . . . 273
get_address_ready_delay() . . . 274
set_data_valid_delay() . . . 276
get_data_valid_delay() . . . 278
set_data_ready_delay() . . . 280
get_data_ready_delay() . . . 281
set_write_response_valid_delay() . . . 283
get_write_response_valid_delay() . . . 284
set_write_response_ready_delay() . . . 286
get_write_response_ready_delay() . . . 287
set_data_beat_done() . . . 289
get_data_beat_done() . . . 291
set_transaction_done() . . . 293
get_transaction_done() . . . 295
execute_transaction() . . . 297
execute_write_addr_phase() . . . 299

execute_read_addr_phase() . . . 301
execute_write_data_burst() . . . 303
execute_write_data_phase() . . . 305
get_read_data_burst() . . . 307
get_read_data_phase() . . . 309
get_write_response_phase() . . . 311
get_read_addr_ready() . . . 313
get_read_data_cycle() . . . 314
execute_read_data_ready() . . . 315
get_write_addr_ready() . . . 316
get_write_data_ready() . . . 317
get_write_response_cycle() . . . 318
execute_write_resp_ready() . . . 319
push_transaction_id() . . . 320
pop_transaction_id() . . . 322
print() . . . 324
destruct_transaction() . . . 326
wait_on() . . . 328

**Chapter 9**
**VHDL AXI3 and AXI4 Slave BFMs . . . 331**

Slave BFM Protocol Support . . . 331
Slave Timing and Events . . . 331
Slave BFM Configuration . . . 332
Slave Assertions . . . 334
AXI3 Assertion Configuration . . . 335
AXI4 Assertion Configuration . . . 336
VHDL Slave API . . . 336
set_config() . . . 337
get_config() . . . 339
create_slave_transaction() . . . 341
set_addr() . . . 345
get_addr() . . . 346
set_size() . . . 348
get_size() . . . 349
set_burst() . . . 351
get_burst() . . . 352
set_lock() . . . 354
get_lock() . . . 355
set_cache() . . . 357
get_cache() . . . 359
set_prot() . . . 361
get_prot() . . . 362
set_id() . . . 364
get_id() . . . 365
set_burst_length() . . . 367
get_burst_length() . . . 368
set_data_words() . . . 370

get_data_words() . . . . . 372
set_write_strobes() . . . . . 374
get_write_strobes() . . . . . 375
set_resp(). . . . . 377
get_resp() . . . . . 379
set_addr_user() . . . . . 381
get_addr_user() . . . . . 382
set_read_or_write() . . . . . 384
get_read_or_write() . . . . . 385
set_gen_write_strobes() . . . . . 387
get_gen_write_strobes() . . . . . 388
set_operation_mode() . . . . . 390
get_operation_mode() . . . . . 392
set_delay_mode() . . . . . 394
get_delay_mode() . . . . . 396
set_write_data_mode() . . . . . 398
get_write_data_mode() . . . . . 399
set_address_valid_delay(). . . . . 401
get_address_valid_delay() . . . . . 402
set_address_ready_delay() . . . . . 404
get_address_ready_delay() . . . . . 405
set_data_valid_delay() . . . . . 407
get_data_valid_delay() . . . . . 409
set_data_ready_delay() . . . . . 411
get_data_ready_delay(). . . . . 412
set_write_response_valid_delay() . . . . . 414
get_write_response_valid_delay() . . . . . 416
set_write_response_ready_delay() . . . . . 418
get_write_response_ready_delay() . . . . . 419
set_data_beat_done() . . . . . 421
get_data_beat_done() . . . . . 423
set_transaction_done() . . . . . 425
get_transaction_done() . . . . . 427
execute_read_data_burst() . . . . . 429
execute_read_data_phase(). . . . . 431
execute_write_response_phase() . . . . . 433
get_write_addr_phase() . . . . . 435
get_read_addr_phase() . . . . . 437
get_write_data_phase(). . . . . 439
get_write_data_burst() . . . . . 441
get_read_addr_cycle() . . . . . 443
execute_read_addr_ready(). . . . . 444
get_read_data_ready() . . . . . 445
get_write_addr_cycle() . . . . . 446
execute_write_addr_ready() . . . . . 447
get_write_data_cycle() . . . . . 448
execute_write_data_ready() . . . . . 449
get_write_resp_ready() . . . . . 450
push_transaction_id() . . . . . 451

pop_transaction_id() . . . 453
print() . . . 455
destruct_transaction() . . . 457
wait_on() . . . 459
Helper Functions . . . 461
get_write_addr_data() . . . 461
get_read_addr() . . . 464
set_read_data() . . . 467

Chapter 10
VHDL AXI3 and AXI4 Monitor BFMs . . . 471

Inline Monitor Connection . . . 471
Monitor BFM Protocol Support . . . 472
Monitor Timing and Events . . . 472
Monitor BFM Configuration . . . 472
Monitor Assertions . . . 475
AXI3 Assertion Configuration . . . 476
AXI4 Assertion Configuration . . . 477
VHDL Monitor API . . . 477
set_config() . . . 478
get_config() . . . 480
create_monitor_transaction() . . . 482
set_addr() . . . 486
get_addr() . . . 487
set_size() . . . 489
get_size() . . . 490
set_burst() . . . 492
get_burst() . . . 493
set_lock() . . . 495
get_lock() . . . 496
set_cache() . . . 498
get_cache() . . . 500
set_prot() . . . 502
get_prot() . . . 503
set_id() . . . 505
get_id() . . . 506
set_burst_length() . . . 508
get_burst_length() . . . 509
set_data_words() . . . 511
get_data_words() . . . 512
set_write_strobes() . . . 514
get_write_strobes() . . . 515
set_resp() . . . 517
get_resp() . . . 518
set_addr_user() . . . 520
get_addr_user() . . . 521
set_read_or_write() . . . 523
get_read_or_write() . . . 524

set_gen_write_strobes() . . . . . 526
get_gen_write_strobes() . . . . . 527
set_operation_mode() . . . . . 529
get_operation_mode() . . . . . 531
set_delay_mode() . . . . . 533
get_delay_mode() . . . . . 534
set_write_data_mode() . . . . . 535
get_write_data_mode() . . . . . 536
set_address_valid_delay() . . . . . 538
get_address_valid_delay() . . . . . 539
set_address_ready_delay() . . . . . 541
get_address_ready_delay() . . . . . 542
set_data_valid_delay() . . . . . 544
get_data_valid_delay() . . . . . 545
set_data_ready_delay() . . . . . 547
get_data_ready_delay() . . . . . 548
set_write_response_valid_delay() . . . . . 550
get_write_response_valid_delay() . . . . . 551
set_write_response_ready_delay() . . . . . 553
get_write_response_ready_delay() . . . . . 554
set_data_beat_done() . . . . . 556
get_data_beat_done() . . . . . 557
set_transaction_done() . . . . . 559
get_transaction_done() . . . . . 560
get_read_data_burst() . . . . . 562
get_read_data_phase() . . . . . 564
get_write_response_phase() . . . . . 566
get_write_addr_phase() . . . . . 568
get_read_addr_phase() . . . . . 570
get_write_data_phase() . . . . . 572
get_write_data_burst() . . . . . 574
get_rw_transaction() . . . . . 576
get_read_addr_ready() . . . . . 578
get_read_data_ready() . . . . . 579
get_write_addr_ready() . . . . . 580
get_write_data_ready() . . . . . 581
get_write_resp_ready() . . . . . 582
push_transaction_id() . . . . . 583
pop_transaction_id() . . . . . 585
print() . . . . . 587
destruct_transaction() . . . . . 589
wait_on() . . . . . 591

**Chapter 11**
**VHDL Tutorials . . . . . 593**
Verifying a Slave DUT . . . . . 593
AXI3 BFM Master Test Program . . . . . 594
AXI4 BFM Master Test Program . . . . . 596
Verifying a Master DUT . . . . . 601
AXI3 BFM Slave Test Program . . . . . 602
AXI3 Basic Slave API Definition . . . . . 602
AXI3 Advanced Slave API Definition . . . . . 608
AXI4 BFM Slave Test Program . . . . . 615

**Chapter 12**
**Getting Started with Qsys and the BFMs . . . . . 629**
Setting Up Simulation from a UNIX Platform . . . . . 629
Setting Up Simulation from the Windows GUI . . . . . 630
Running the Qsys Tool . . . . . 632
Running Simulation . . . . . 635
Invoking Simulation From a GUI . . . . . 636
Invoking Simulation From a UNIX Command Line . . . . . 637
Example Script Processing . . . . . 637
Using a Shortcut or Editing the modelsim.ini File . . . . . 639

**Appendix A**
**Assertions . . . . . 641**
AXI3 Assertions . . . . . 641
AXI4 Assertions . . . . . 654

**Appendix B**
**SystemVerilog AXI3 and AXI4 Test Programs . . . . . 669**
SystemVerilog AXI3 Master BFM Test Program . . . . . 669
SystemVerilog AXI3 Slave BFM Test Program . . . . . 673
SystemVerilog AXI4 Master BFM Test Program . . . . . 678
SystemVerilog AXI4 Slave BFM Test Program . . . . . 682

**Appendix C**
**VHDL AXI3 and AXI4 Test Programs . . . . . 687**
VHDL AXI3 Master BFM Test Program . . . . . 687
VHDL AXI3 Slave BFM Test Program . . . . . 692
VHDL AXI4 Master BFM Test Program . . . . . 698
VHDL AXI4 Slave BFM Test Program . . . . . 703

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# List of Examples


Example 1-1. AXI3 Transaction Definition . . . . . 8
Example 1-2. AXI4 Transaction Definition . . . . . 9
Example 1-3. Slave Test Program Using get_write_addr_phase() . . . . . 15
Example 6-1. Configuration and Initialization . . . . . 132
Example 6-2. Write Transaction Creation and Execution . . . . . 133
Example 6-3. Read Transaction Creation and Execution . . . . . 134
Example 6-4. master_ready_delay_mode . . . . . 136
Example 6-5. m_wr_resp_phase_ready_delay . . . . . 136
Example 6-6. m_rd_data_phase_ready_delay . . . . . 136
Example 6-7. Configuration and Initialization . . . . . 137
Example 6-8. Write Transaction Creation and Execution . . . . . 138
Example 6-9. Read Transaction Creation and Execution . . . . . 138
Example 6-10. Write Burst Transaction Creation and Execution . . . . . 139
Example 6-11. handle_write_resp_ready() . . . . . 141
Example 6-12. internal memory . . . . . 144
Example 6-13. do_byte_read() . . . . . 144
Example 6-14. do_byte_write() . . . . . 144
Example 6-15. set_read_address_ready_delay() . . . . . 145
Example 6-16. set_write_address_ready_delay() . . . . . 145
Example 6-17. set_write_data_ready_delay() . . . . . 146
Example 6-18. set_read_data_valid_delay() . . . . . 146
Example 6-19. set_wr_resp_valid_delay() . . . . . 147
Example 6-20. slave_mode . . . . . 147
Example 6-21. Initialization and Transaction Processing . . . . . 149
Example 6-22. process_read . . . . . 150
Example 6-23. set_read_data_ready() . . . . . 150
Example 6-24. handle_read . . . . . 151
Example 6-25. process_write . . . . . 152
Example 6-26. handle_write . . . . . 152
Example 6-27. internal memory . . . . . 154
Example 6-28. do_byte_read() . . . . . 154
Example 6-29. do_byte_write() . . . . . 154
Example 6-30. m_rd_addr_phase_ready_delay . . . . . 155
Example 6-31. m_wr_addr_phase_ready_delay . . . . . 155
Example 6-32. m_wr_data_phase_ready_delay . . . . . 155
Example 6-33. set_read_data_valid_delay() . . . . . 156
Example 6-34. set_wr_resp_valid_delay() . . . . . 156
Example 6-35. slave_ready_delay_mode . . . . . 158
Example 6-36. slave_mode . . . . . 158
Example 6-37. Initialization and Transaction Processing . . . . . 160

Example 6-38. process_read() . . . . . 161
Example 6-39. handle_read . . . . . 162
Example 6-40. process_write. . . . . 163
Example 6-41. handle_write() . . . . . 164
Example 6-42. handle_write_addr_ready() . . . . . 165
Example 7-1. AXI3 Transaction Definition . . . . . 171
Example 7-2. AXI4 Transaction Definition . . . . . 172
Example 7-3. Slave BFM Test Program Using get_write_addr_phase() . . . . . 179
Example 11-1. Architecture Definition and Initialization . . . . . 594
Example 11-2. Write Transaction Creation and Execution . . . . . 595
Example 11-3. Read Transaction Creation and Execution . . . . . 595
Example 11-4. m_wr_resp_phase_ready_delay . . . . . 596
Example 11-5. m_rd_data_phase_ready_delay . . . . . 596
Example 11-6. Wait for *ARESETn D*eassertion Then Positive *ACLK* Edge . . . . . 597
Example 11-7. Write Transaction Creation and Execution . . . . . 597
Example 11-8. Read Transaction Creation and Execution . . . . . 598
Example 11-9. Write Burst Transaction Creation and Execution . . . . . 599
Example 11-10. Process handle_write_resp_ready . . . . . 600
Example 11-11. internal memory . . . . . 602
Example 11-12. do_byte_read() . . . . . 603
Example 11-13. do_byte_write() . . . . . 603
Example 11-14. set_read_address_ready_delay() . . . . . 603
Example 11-15. set_write_address_ready_delay() . . . . . 604
Example 11-16. set_write_data_ready_delay() . . . . . 605
Example 11-17. set_read_data_valid_delay() . . . . . 606
Example 11-18. set_wr_resp_valid_delay() . . . . . 607
Example 11-19. slave_mode . . . . . 607
Example 11-20. process write . . . . . 610
Example 11-21. handle_write . . . . . 611
Example 11-22. handle_response . . . . . 612
Example 11-23. process_read . . . . . 613
Example 11-24. handle read . . . . . 614
Example 11-25. Internal Memory . . . . . 615
Example 11-26. m_wr_addr_phase_ready_delay . . . . . 616
Example 11-27. m_rd_addr_phase_ready_delay. . . . . 617
Example 11-28. m_wr_data_phase_ready_delay . . . . . 617
Example 11-29. set_wr_resp_valid_delay() . . . . . 617
Example 11-30. set_read_data_valid_delay() . . . . . 618
Example 11-31. process_read . . . . . 621
Example 11-32. handle_read . . . . . 622
Example 11-33. process_write. . . . . 623
Example 11-34. handle_write . . . . . 624
Example 11-35. handle_response . . . . . 625
Example 11-36. handle_write_addr_ready . . . . . 626

# List of Figures


Figure 1-1. SystemVerilog BFM Internal Structure . . . . . 6
Figure 1-2. Valid Data on Byte Lanes During a Write Transaction . . . . . 17
Figure 1-3. Operational Transaction Field delay_mode = AXI_VALID2READY. . . . . 22
Figure 1-4. Operational Transaction Field delay_mode = AXI_TRANS2READY . . . . . 22
Figure 2-1. Execute WriteTransaction. . . . . 27
Figure 2-2. Master Write Transaction Phases . . . . . 27
Figure 2-3. Slave Write Transaction Phases . . . . . 28
Figure 2-4. Master Read Transaction Phases. . . . . 29
Figure 2-5. Slave Read Transaction Phases. . . . . 30
Figure 5-1. Inline Monitor Connection Diagram. . . . . 99
Figure 6-1. Slave DUT Top-level Testbench Environment. . . . . 131
Figure 6-2. master_ready_delay_mode = AXI4_VALID2READY . . . . . 135
Figure 6-3. master_ready_delay_mode = AXI4_TRANS2READY . . . . . 135
Figure 6-4. Master DUT Top-level Testbench Environment. . . . . 142
Figure 6-5. Slave Test Program Advanced API Tasks . . . . . 149
Figure 6-6. slave_ready_delay_mode = AXI4_VALID2READY . . . . . 157
Figure 6-7. slave_ready_delay_mode = AXI4_TRANS2READY . . . . . 157
Figure 6-8. Slave Test Program Advanced API Tasks . . . . . 160
Figure 7-1. VHDL BFM Internal Structure. . . . . 168
Figure 7-2. Valid Data on Byte Lanes During a Write Transaction . . . . . 181
Figure 7-3. Operational Transaction Field delay_mode = AXI_VALID2READY. . . . . 185
Figure 7-4. Operational Transaction Field delay_mode = AXI_TRANS2READY . . . . . 185
Figure 10-1. Inline Monitor Connection Diagram. . . . . 471
Figure 11-1. Slave DUT Top-level Testbench Environment. . . . . 593
Figure 11-2. Master DUT Top-level Testbench Environment. . . . . 601
Figure 11-3. Slave Test Program Advanced API Tasks . . . . . 609
Figure 11-4. Slave Test Program Advanced API Processes . . . . . 620
Figure 12-1. Copy the Contents of *qsys-examples* from the Installation Folder . . . . . 630
Figure 12-2. Paste *qsys-examples* from Installation Folder into Work Folder . . . . . 631
Figure 12-3. Select Qsys from the Quartus II Software Top-Level Menu . . . . . 632
Figure 12-4. Open the *ex1_back_to_back_sv.qsys* Example . . . . . 632
Figure 12-5. Quartus II Software Displays Connectivity of the Example . . . . . 633
Figure 12-6. Generation Tab Window . . . . . 633
Figure 12-7. Set Path, Simulation, and Synthesis Options . . . . . 634
Figure 12-8. Click Generate . . . . . 635
Figure 12-9. Select the Work Directory. . . . . 636

# List of Tables


Table 1. Simulator GCC Requirements . . . . . 3
Table 1-1. Transaction Fields . . . . . 10
Table 1-2. Handshake Signal Delay Transaction Fields . . . . . 19
Table 1-3. Master and Slave*_valid_delay Configuration Fields . . . . . 20
Table 1-4. Master &Slave *_*ready_delay* Transaction Fields . . . . . 21
Table 3-1. Master BFM Signal Width Parameters . . . . . 33
Table 3-2. Master BFM Configuration . . . . . 33
Table 4-1. Slave BFM Signal Width Parameters . . . . . 67
Table 4-2. Slave BFM Configuration . . . . . 67
Table 5-1. AXI Monitor BFM Signal Width Parameters . . . . . 101
Table 5-2. AXI Monitor BFM Configuration . . . . . 102
Table 7-1. Transaction Fields . . . . . 173
Table 7-2. Handshake Signal Delay Transaction Fields . . . . . 183
Table 7-3. Master and Slave *valid_delay Configuration Fields . . . . . 184
Table 7-4. Master and Slave *_ready_delay Fields . . . . . 184
Table 8-1. Master BFM Signal Width Parameters . . . . . 188
Table 8-2. Master BFM Configuration . . . . . 189
Table 9-1. Slave BFM Signal Width Parameters . . . . . 332
Table 9-2. Slave BFM Configuration . . . . . 333
Table 10-1. Signal Parameters . . . . . 472
Table 10-2. AXI Monitor BFM Configuration . . . . . 473
Table 12-1. Simulator and Script Names . . . . . 636
Table A-1. AXI3 Assertions . . . . . 641
Table A-2. AXI4 Assertions . . . . . 654

# Preface

## About This User Guide

This Mentor® Verification IP (VIP) Altera® Edition (AE) User Guide describes the application interface (API) of the Mentor VIP AE and how it conforms to the AMBA® AXI and ACE Protocol Specification, AXI3™, AXI4T™, and AXI-Lite™, ACE and ACE-Lite™ (ARM IHI 0022D).

**Note**

This release supports only the AMBA AXI3 and AXI4 protocols; the AMBA AXI4-Lite, AXI4-Stream™, and AMBA ACE protocols are not supported in this release.

## AMBA AXI Protocol Specification

The Mentor VIP AE conforms to the AMBA® AXI and ACE Protocol Specification, AXI3™, AXI4T™, and AXI-Lite™, ACE and ACE-Lite™ (ARM IHI 0022D). For restrictions to this protocol, refer to the section Protocol Restrictions.

This user guide refers to the AMBA® AXI and ACE Protocol Specification, AXI3™, AXI4™, and AXI-Lite™, ACE and ACE-Lite™ as the AXI protocol specification.

## Protocol Restrictions

The Mentor VIP AE supports all but the following features of this AXI Specification, which gives you a simplified API to create desired protocol stimulus.

### BFM Dependencies Between Handshake Signals

Starting a write data phase before its write address phase in a transaction is not supported. However, starting a write data phase simultaneously with its write address phase is supported.

The above statement disallowing a write data phase to start before its write address phase in a transaction modifies the AXI3 protocol specification write transaction handshake dependencies diagram, Figure A3-6 in section A3.3.1, by effectively adding double-headed arrows between *AWVALID* to *WVALID* and *AWREADY* to *WVALID*, with the provision that they can be simultaneous.

The above statement disallowing a write data phase to start before its write address phase in a transaction modifies the AXI4 protocol specification slave write response handshake dependencies diagram, Figure A3-7 in section A3.3.1, by effectively adding double-headed arrows between *AWVALID* to *WVALID* and *AWREADY* to *WVALID*, with the provision that they can be simultaneous.

## AXI3 BFM Write Data Interleaving

The ability of a BFM to interleave write data is not supported. Therefore, a write data burst that has started will complete before another write data burst with the same or different transaction ID can start. An AXI3 BFM modifies the AXI protocol specification by removing section A5.3.3 concerning the interleaving of write data with different *AWID* signal values.

## BFM Read Data Interleaving

The ability of a BFM to interleave read data is not supported. Therefore, a read data burst that has started will complete before another read data burst with the same or different transaction ID can start. A BFM modifies the AXI protocol specification by changing the following statement in section A5.3.1 concerning the interleaving of read data with different *ARID* signal values.

- Read data of transactions with different *ARID* values **cannot** be interleaved.

# Supported Simulators

Mentor VIP AE supports the following simulators:

- Mentor Graphics Modelsim (including Altera Editions) and Questa Sim 10.1d
- Synopsys VCS and VCS-MX 2012.09
- Cadence Incisive Enterprise Simulator (IES) 12.10.013

# Simulator GCC Requirements

Mentor Verification IP requires that the simulator's installation directory includes the GCC libraries shown in Table 1. If the installation of the GCC libraries was an optional part of the simulator's installation and the Mentor VIP does not find these libraries, you will see an error similar to the following error:

```
ModelSim / Questa Sim
# ** Error: (vsim-8388) Could not find the MVC shared library : GCC not
found in installation directory (/home/user/altera2/12.1/modelsim_ase) for
platform "linux".  Please install GCC version "gcc-4.5.0-linux"
```

**Table 1. Simulator GCC Requirements**

| Simulator | Version | GCC version(s) | Search Path |
|---|---|---|---|
| **Mentor Questa SIM /ModelSim** | | | |
| | 10.1d | 4.5.0 (Linux 32-bit) | <install dir>/gcc-4.5.0-linux |
| | | 4.5.0 (Linux 64-bit) | <install dir>/gcc-4.5.0-linux_x86_64 |
| | | 4.2.1 (Windows 32-bit) | <install dir>/gcc-4.2.1-mingw32vc9 |
| **Synopsys VCS/VCS-MX** | | | |
| | 2012.09 | 4.2.2 (Linux 32-bit) | $VCS_HOME/gnu/linux/4.2.2_32-shared<br>$VCS_HOME/gnu/4.2.2_32-shared |
| | | 4.2.2 (Linux 64-bit) | $VCS_HOME/gnu/linux/4.2.2_64-shared<br>$VCS_HOME/gnu/4.2.2_64-shared |
| | Notes: If the environment variable VG_GNU_PACKAGE is set, this variable is used instead of the VCS_HOME environment variable.<br><br>GCC Version 4.5.2 is the default version for VCS 2012.09. To use GCC 4.2.2, you must ensure that this version is installed separately and that the environment variable VG_GNU_PACKAGE is set appropriately. Refer to the VCS documentation for information about installing the GCC 4.2.2 package and pointing VCS to a nondefault GCC version. | | |
| **Cadence Incisive Enterprise Simulator** | | | |
| | 12.10.013 | 4.4 (Linux 32/64-bit) | <install dir>/tools/cdsgcc/gcc/4.4 |
| | Note: Use the cds_tools.sh executable to find the Incisive installation. Ensure $PATH includes the Installation path and <install dir>/tools/cdsgcc/gcc/4/4/install/bin. Also, ensure the LD_LIBRARY_PATH includes <install dir>/tools/cdsgcc/gcc/4/4/install/lib | | |

# AXI3 and AXI4 Syntax References

Throughout this user guide, when an AXI3 or AXI4 protocol argument is referenced, the syntax *axi* or *axi4* is used, with *axi* used for AXI3 protocol arguments and *axi4* used for AXI4 protocol arguments. Uppercase *AXI3* and *AXI4* is used for enumerated arguments. When a task is applicable to both AXI3 and AXI4 protocols, either a single (*) or double asterisk (**) is used in the syntax description. A single asterisk is used for nonenumerated arguments; a double asterisk is used for enumerated arguments.

# Chapter 1
# Mentor VIP Altera Edition

The Mentor® Verification IP (VIP) Altera® Edition (AE) provides bus functional models (BFMs) to simulate the behavior and to facilitate IP verification. The Mentor VIP AE includes the following interfaces:

- AXI3™ BFM with master, slave, and inline monitor interfaces
- AXI4™ BFM with master, slave, and inline monitor interfaces

## Advantages of Using BFMs and Monitors

Using the Mentor VIP AE has the following advantages:

- Accelerates the verification process by providing key verification testbench components.
- Provides BFM components that implement the AMBA AXI Protocol Specification, which serves as a reference for the protocol.
- Provides a full suite of configurable assertion checking in each BFM.

## Implementation of BFMs

The Mentor VIP AE BFMs, master, slave, and inline monitor components are implemented in SystemVerilog. Also included are wrapper components so that the BFMs can be used in VHDL verification environments with simulators that support mixed-language simulation.

The Mentor VIP AE provides a set of APIs for each BFM that you can use to construct, instantiate, control, and query signals in all BFM components. Your test programs must use only these public access methods and events to communicate with each BFM. To ensure support in current and future releases, your test programs must use the standard set of APIs to interface with the BFMs. Nonstandard APIs and user-generated interfaces can not be supported in future releases.

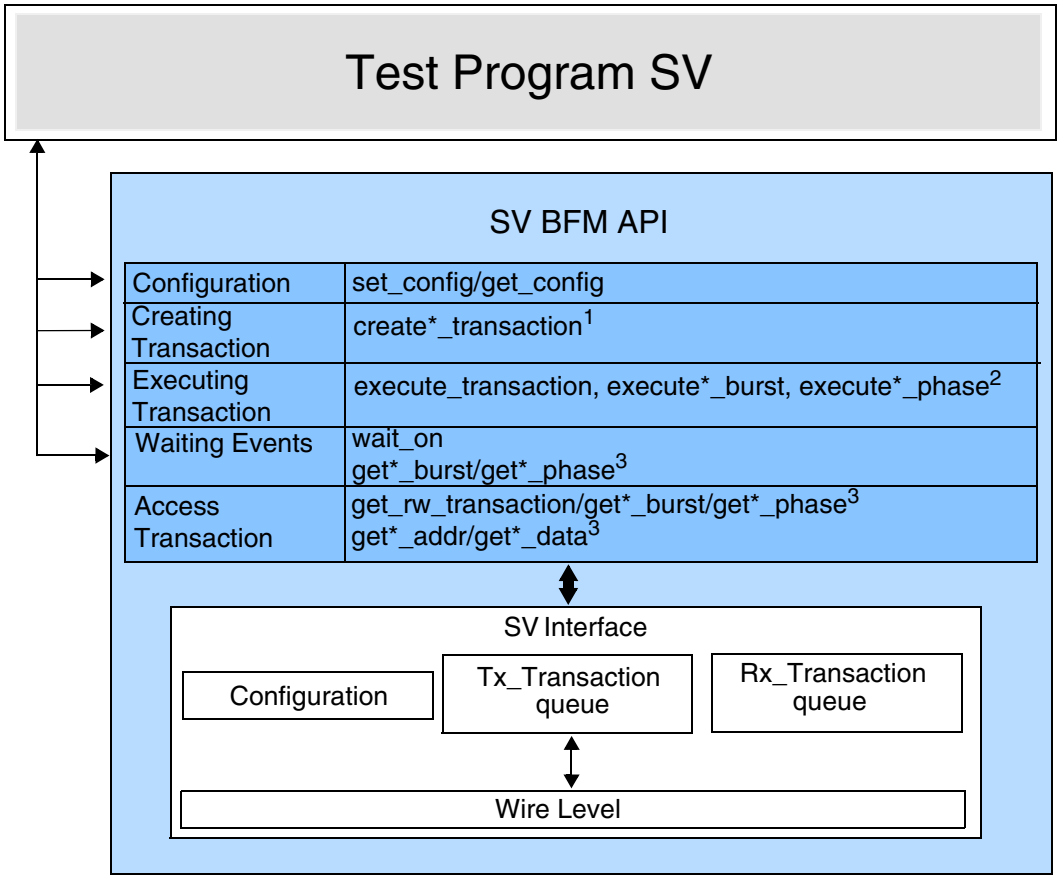
The test program drives the stimulus to the DUTs and determines whether the DUTs' behavior is correct by analyzing the responses. The BFMs translate the test program stimuli, creating the signaling for the AMBA AXI Protocol Specification. The BFMs also check for protocol compliance by firing an assertion when a protocol error is observed.

# SystemVerilog API Overview

This section provides the functional description of the SystemVerilog Application Programming Interface (API) for all the BFM (master, slave, and monitor) components. For each BFM, you can configure the protocol transaction fields that are executed on the protocol signals, as well as control the operational transaction fields that permit delays to be introduced between the handshake signals for each of the five address, data, and response channels.

In addition, each BFM API has tasks that wait for certain events to occur on the system clock and reset signals, and tasks to get and set information about a particular transaction.

**Figure 1-1. SystemVerilog BFM Internal Structure**




**Notes:** 1. Refer to create*_transaction()
2. Refer to execute_transaction(), execute*_burst(), execute*_phase()
3. Refer to get*()

# Configuration

Configuration sets timeout delays, error reporting, and other attributes of the BFM. Each BFM has a *set_config()* function that sets the configuration of the BFM. Refer to the individual BFM APIs for details.

Each BFM also has a *get_config()* function that returns the configuration of the BFM. Refer to the individual BFM APIs for details.

## set_config()

The following test program code sets the burst timeout factor for a transaction in the master BFM.

```
// Setting the burst timeoutfactor to 1000
master_bfm.set_config(AXI_CONFIG_BURST_TIMEOUT_FACTOR, 1000);
```

**Note**

The above test program code segment is for AXI3 BFMs. Substitute the *AXI_CONFIG_BURST_TIMEOUT_FACTOR* enumeration with *AXI4_CONFIG_BURST_TIMEOUT_FACTOR* for AXI4 BFMs.

## get_config()

The following test program code gets the protocol signal hold time in the master BFM.

```
 // Getting hold time value
hold_time = master_bfm.get_config(AXI_CONFIG_HOLD_TIME);
```

**Note**

The above test program code segment is for AXI3 BFMs. Substitute the *AXI_CONFIG_HOLD_TIME* enumeration with *AXI4_CONFIG_HOLD_TIME* for AXI4 BFMs.

# Creating Transactions

To transfer information between a master BFM and slave DUT over the protocol signals a transaction must be created in the master test program. Similarly, to transfer information between a master DUT and a slave BFM a transaction must be created in the slave test program. To monitor the transfer of information using a monitor BFM, a transaction must be created in the monitor test program.

When you create a transaction, a Transaction Record is created and exists for the life of the transaction. This transaction record can be accessed by the BFM test programs during the life of the transaction as it transfers information between the master and slave.

# Transaction Record

The transaction record contains two types of transaction fields, *protocol* and *operational,* that either transfer information over the protocol signals or define how and when a transfer occurs.

Protocol fields contain transaction information that is transferred over protocol signals. For example, the *prot* field is transferred over the *AWPROT* protocol signals during a write transaction.

Operational fields define how and when the transaction is transferred. Their content is not transferred over protocol signals. For example, the *operation_mode* field controls the blocking/nonblocking operation of a transaction, but this information is not transferred over the protocol signals.

## AXI3 Transaction Definition

The transaction record exists as a SystemVerilog class definition in each BFM. Example 1-1 shows the definition of the *axi_transaction* class members that form the transaction record.

**Example 1-1. AXI3 Transaction Definition**

```
// Global Transaction Class
class axi_transaction;
    // Protocol
    bit [((`MAX_AXI_ADDRESS_WIDTH) - 1):0]  addr;
    axi_size_e size;
    axi_burst_e burst;
    axi_lock_e lock;
    axi_cache_e cache;
    axi_prot_e prot;
    bit [((`MAX_AXI_ID_WIDTH) - 1):0]  id;
    bit [3:0] burst_length;
    bit [(((`MAX_AXI_RDATA_WIDTH > `MAX_AXI_WDATA_WIDTH) ?
`MAX_AXI_RDATA_WIDTH : `MAX_AXI_WDATA_WIDTH)) - 1):0] data_words [];
    bit [(((`MAX_AXI_WDATA_WIDTH / 8)) - 1):0] write_strobes [];
    axi_response_e resp[];
    bit [7:0] addr_user;
    axi_rw_e read_or_write;
    int address_valid_delay;
    int data_valid_delay[];
    int write_response_valid_delay;
    int address_ready_delay;
    int data_ready_delay[];
    int write_response_ready_delay;
// Housekeeping
    bit gen_write_strobes = 1'b1;
    axi_operation_mode_e  operation_mode  = AXI_TRANSACTION_BLOCKING;
    axi_delay_mode_e      delay_mode      = AXI_VALID2READY;
    axi_write_data_mode_e write_data_mode = AXI_DATA_AFTER_ADDRESS;
    bit data_beat_done[];
    bit transaction_done;
...
endclass
```

**Note**

The *axi_transaction* class code above is shown for information only. Access to each transaction record during its life is performed by various *set*()* and *get*()* tasks described later in this chapter.

## AXI4 Transaction Definition

The transaction record exists as a SystemVerilog class definition in each BFM. Example 1-2 shows the definition of the *axi4_transaction* class members that form the transaction record.

**Example 1-2. AXI4 Transaction Definition**

```
// Global Transaction Class
class axi4_transaction;
    // Protocol
    axi4_rw_e read_or_write;
    bit [((`MAX_AXI4_ADDRESS_WIDTH) - 1):0]  addr;
    axi4_prot_e prot;
    bit [3:0] region;
    axi4_size_e size;
    axi4_burst_e burst;
    axi4_lock_e lock;
    axi4_cache_e cache;
    bit [3:0] qos;
    bit [((`MAX_AXI4_ID_WIDTH) - 1):0]  id;
    bit [7:0] burst_length;
    bit [((`MAX_AXI4_USER_WIDTH) - 1):0]  addr_user;
    bit [(((`MAX_AXI4_RDATA_WIDTH > `MAX_AXI4_WDATA_WIDTH) ?
`MAX_AXI4_RDATA_WIDTH : `MAX_AXI4_WDATA_WIDTH)) - 1):0] data_words [];
    bit [(((`MAX_AXI4_WDATA_WIDTH / 8)) - 1):0] write_strobes [];
    axi4_response_e resp[];
    int address_valid_delay;
    int data_valid_delay[];
    int write_response_valid_delay;
    int address_ready_delay;
    int data_ready_delay[];
    int write_response_ready_delay;

    // Housekeeping
    bit gen_write_strobes = 1'b1;
    axi4_operation_mode_e  operation_mode  = AXI4_TRANSACTION_BLOCKING;
    axi4_write_data_mode_e write_data_mode = AXI4_DATA_AFTER_ADDRESS;
    bit data_beat_done[];
    bit transaction_done;

...

endclass
```

**Note**

The *axi4_transaction* class code above is shown for information only. Access to each transaction record during its life is performed by various *set*()* and *get*()* tasks described later in this chapter.

The contents of the transaction record is defined in Table 1-1 below.

**Table 1-1. Transaction Fields**

| Transaction Field | Description |
|---|---|
| **Protocol Transaction Fields** | |
| addr | A bit vector (the length is equal to the *ARADDR/AWADDR* signal bus width) containing the starting *address* of the first transfer (beat) of a transaction. The *addr* value is transferred over the *ARADDR* or *AWADDR* signals for a read or write transaction, respectively. |
| prot | An enumeration containing the *protection* type of a transaction. The types of *protection* are:<br>**_NORM_SEC_DATA (default)<br>**_PRIV_SEC_DATA<br>**_NORM_NONSEC_DATA<br>**_PRIV_NONSEC_DATA<br>**_NORM_SEC_INST<br>**_PRIV_SEC_INST<br>**_NORM_NONSEC_INST<br>**_PRIV_NONSEC_INST<br>The *prot* value is transferred over the *ARPROT* or *AWPROT* signals for a read or write transaction, respectively. |
| region | (AXI4) A 4-bit vector containing the *region* identifier of a transaction. The *region* value is transferred over the *ARREGION* or *AWREGION* signals for a read or write transaction, respectively. |
| size | An enumeration to hold the *size* of a transaction. The types of *size* are:<br>**_BYTES_1<br>**_BYTES_2<br>**_BYTES_4<br>**_BYTES_8<br>**_BYTES_16<br>**_BYTES_32<br>**_BYTES_64<br>**_BYTES_128<br>The *size* value is transferred over the *ARSIZE* or *AWSIZE* signals for a read or write transaction, respectively. |
| burst | An enumeration to hold the *burst* of a transaction. The types of *burst* are:<br>**_FIXED<br>**_INCR<br>**_WRAP<br>**_BURST_RSVD<br>The *burst* value is transferred over the *ARBURST* or *AWBURST* signals for a read or write transaction, respectively. |

| | |
|---|---|
| lock | An enumeration to hold the *lock* of a transaction. The types of *lock* are:<br><br>**_NORMAL<br>**_EXCLUSIVE<br>(AXI3) AXI_LOCKED<br>(AXI3) AXI_LOCKED_RSVD<br><br>The *lock* value is transferred over the *ARLOCK* or *AWLOCK* signals for a read or write transaction, respectively. |
| cache | (AXI3) An enumeration to hold the *cache* of a transaction. The types of *cache* are:<br><br>AXI_NONCACHE_NONBUF; (default)<br>AXI_BUF_ONLY;<br>AXI_CACHE_NOALLOC;<br>AXI_CACHE_BUF_NOALLOC;<br>AXI_CACHE_RSVD0;<br>AXI_CACHE_RSVD1;<br>AXI_CACHE_WTHROUGH_ALLOC_R_ONLY;<br>AXI_CACHE_WBACK_ALLOC_R_ONLY;<br>AXI_CACHE_RSVD2;<br>AXI_CACHE_RSVD3;<br>AXI_CACHE_WTHROUGH_ALLOC_W_ONLY;<br>AXI_CACHE_WBACK_ALLOC_W_ONLY;<br>AXI_CACHE_RSVD4;<br>AXI_CACHE_RSVD5;<br>AXI_CACHE_WTHROUGH_ALLOC_RW;<br>AXI_CACHE_WBACK_ALLOC_RW;<br>The *cache* value is transferred over the *ARCACHE* or *AWCACHE* signals for a read or write transaction, respectively. |
| cache | (AXI4) An enumeration to hold the *cache* of a transaction. The types of *cache* are:<br><br>AXI4_NONMODIFIABLE_NONBUF<br>AXI4_BUF_ONLY<br>AXI4_CACHE_NOALLOC<br>AXI4_CACHE_2<br>AXI4_CACHE_3<br>AXI4_CACHE_RSVD4<br>AXI4_CACHE_RSVD5<br>AXI4_CACHE_6<br>AXI4_CACHE_7<br>AXI4_CACHE_RSVD8<br>AXI4_CACHE_RSVD9<br>AXI4_CACHE_10<br>AXI4_CACHE_11<br>AXI4_CACHE_RSVD12<br>AXI4_CACHE_RSVD13<br>AXI4_CACHE_14<br>AXI4_CACHE_15<br><br>The *cache* value is transferred over the *ARCACHE* or *AWCACHE* signals for a read or write transaction, respectively. |
| qos | (AXI4) A 4-bit vector to hold the *Quality of Service* (qos) identifier of a transaction. The *qos* value is transferred over the *ARQOS* or *AWQOS* signals for a read or write transaction, respectively. |

| | |
|---|---|
| id | A bit vector (of length equal to the *ARID/AWID* signal bus width) that holds the identification tag of a transaction. The id value is transferred over the *AWID/BID* signals for a write transaction and over the *ARID/RID* signals for a read transaction. |
| burst_length | A 4-bit (8-bit for AXI4) vector to hold the burst length of a transaction. The *burst_length* value is transferred over the *ARLEN* or *AWLEN* signals for a read or write transaction, respectively. |
| addr_user | A bit vector (of length equal to the *ARUSER/AWUSER* signal bus width) to hold the address channel *user data* of a transaction. The *addr_data* value is transferred over the *ARUSER* or *AWUSER* signals for a read or write transaction, respectively. |
| data_words | An unsized array of bit vectors (of length equal to the greater of the *RDATA/WDATA* signal bus widths) to hold the *data words* of the payload. A *data_words* array element is transferred over the *RDATA* or *WDATA* signals per beat of the read or write data channel, respectively. |
| write_strobes | An unsized array of bit vectors (of length equal to the *WDATA* signal bus width divided by 8) to hold the write strobes. A *write_strobes* array element is transferred over the *WSTRB* signals per beat of the write data channel. |
| resp | An unsized enumeration array to hold the responses of a transaction. The types of *response* are:<br><br>**_OKAY;<br>**_EXOKAY;<br>**_SLVERR;<br>**_DECERR;<br><br>A *resp* array element is transferred over the *RRESP* signals per beat of the read data channel, and over the *BRESP* signals for a write transaction, respectively. |

## Operational Transaction Fields

| | |
|---|---|
| read_or_write | An enumeration to hold the *read or write* control flag. The types of *read_or_write* are:<br><br>**_TRANS_READ<br>**_TRANS_WRITE |
| address_valid_delay | An integer to hold the delay value of the address channel *AWVALID and ARVALID* signals (measured in *ACLK* cycles) for a read or write transaction, respectively. |
| data_valid_delay | An unsized array of integers to hold the delay values of the data channel *WVALID and RVALID* signals (measured in *ACLK* cycles) for a read or write transaction, respectively. |
| write_response_valid_delay | An integer to hold the delay value of the write response channel *BVALID* signal (measured in *ACLK* cycles) for a write transaction. |
| address_ready_delay | An integer to hold the delay value of the address channel *AWREADY and ARREADY* signals (measured in *ACLK* cycles) for a read or write transaction, respectively. |

| | |
|---|---|
| data_ready_delay | An unsized array of integers to hold the delay values of the data channel *WREADY and RREADY* signals (measured in *ACLK* cycles) for a read or write transaction, respectively. |
| write_response_ready_delay | An integer to hold the delay value of the write response channel *BREADY* signal (measured in *ACLK* cycles) for a write transaction. |
| gen_write_strobes | Automatically correct write strobes flag. Refer to Automatic Generation of Byte Lane Strobes for details. |
| operation_mode | An enumeration to hold the *operation mode* of the transaction. The two types of *operation_mode* are:<br>**_TRANSACTION_NON_BLOCKING<br>**_TRANSACTION_BLOCKING |
| delay_mode | (AXI3) An enumeration to hold the *delay mode* control flag. The types of *delay_mode* are:<br>AXI_VALID2READY<br>AXI_TRANS2READY<br>Refer to AXI3 BFM Delay Mode for details. |
| write_data_mode | An enumeration to hold the *write data mode* control flag. The types of *write_data_mode* are:<br>**_DATA_AFTER_ADDRESS<br>**_DATA_WITH_ADDRESS |
| data_beat_done | An unsized bit array to hold the *done* flag for each beat in a read or write data burst when it has completed. |
| transaction_done | A bit to hold the *done* flag for a transaction when it has completed. |

The master BFM API allows you to create a master transaction by providing only the address and burst length arguments for a read or write transaction. All other protocol transaction fields automatically default to legal protocol values to create a complete master transaction record. Refer to the *create_read_transaction()* and *create_write_transaction()* functions for default protocol read and write transaction field values.

The slave BFM API allows you to create a slave transaction without providing any arguments. All protocol transaction fields automatically default to legal protocol values to create a complete slave transaction record. Refer to the *create_slave_transaction()* function for default protocol transaction field values.

The monitor BFM API allows you to create a monitor transaction without providing any arguments. All protocol transaction fields automatically default to legal protocol values to create a complete slave transaction record. Refer to the *create_monitor_transaction()* function for default protocol transaction field values.

**Note**

If you change the default value of a protocol transaction field, this value is valid for all future transactions until a new value is set.

## create*_transaction()

There are two master BFM API functions available to create transactions, *create_read_transaction()* and *create_write_transaction()*, a *create_slave_transaction()* for the slave BFM API, and a *create_monitor_transaction()* for the monitor BFM API.

For example, the following master BFM test program creates a simple write transaction with a start address of 1, and a single data phase with a data value of 2, the master BFM test program would contain the following code:

```
// Define a variable trans of type axi_transaction
axi_transaction write_trans;

// Create master write transaction
write_trans = bfm.create_write_transaction(1);
write_trans.data_words[0]   = 2;
```

For example, to create a simple slave transaction the slave BFM test program would contain the following code:

```
// Define a variable slave_trans of type axi_transaction
axi_transaction slave_trans;

// Create slave transaction
slave_trans = bfm.create_slave_transaction();
```

**Note**

The above test program code segments are for AXI3 BFMs. Substitute the *axi_transaction* type definition with *axi4_transaction* for AXI4 BFMs.

# Executing Transactions

Executing a transaction in a master/slave BFM test program initiates the transaction onto the protocol signals. Each master/slave BFM API has execution tasks that push transactions into the BFM internal transaction queues. Figure 1-1 on page 6 illustrates the internal BFM structure.

## execute_transaction(), execute*_burst(), execute*_phase()

If the DUT is a slave, then the *execute_transaction()* task is called in the master BFM test program. If the DUT is a master, then the *execute*_burst()* and *execute*_phase()* tasks are called in the slave BFM test program.

For example, to execute a master write transaction the master BFM test program contains the following code:

```
// By default the execution of a transaction will block
bfm.execute_transaction(write_trans);
```

For example, to execute a slave write response phase, the slave BFM test program contains the following code:

```
// By default the execution of a transaction will block
bfm.execute_write_response_phase(slave_trans);
```

# Waiting Events

Each BFM API has tasks that block the test program code execution until an event has occurred.

The *wait_on()* task blocks the test program until an *ACLK* or *ARESETn* signal event has occurred before proceeding.

The *get*_transaction(), get*_burst(), get*_phase(), get*_cycle()* tasks block the test program code execution until a complete transaction, burst, phase or cycle has occurred, respectively.

## wait_on()

For example, a BFM test program can wait for the positive edge of the *ARESETn* signal using the following code:

```
// Block test program execution until the positive edge of the clock
bfm.wait_on(AXI_RESET_POSEDGE);
```

**Note**

The above test program code segments are for AXI3 BFMs. Substitute the *AXI_RESET_POSEDGE* enumeration with *AXI4_RESET_POSEDGE* for AXI4 BFMs.

## get*_transaction(), get*_burst(), get*_phase(), get*_cycle()

For example, a slave BFM test program can use a received write address phase to form the response of the write transaction. The test program gets the write address phase for the transaction by calling the *get_write_addr_phase()* task. This task blocks until it has received the address phase, allowing the test program to call the *execute_write_response_phase()* task for the transaction at a later stage, as shown in the slave BFM test program in Example 1-3.

**Example 1-3. Slave Test Program Using get_write_addr_phase()**

```
slave_trans = bfm.create_slave_transaction();
bfm.get_write_addr_phase(slave_trans);

...

bfm.execute_write_response_phase(slave_trans);
```

**Note**

Not all BFM APIs support the full complement of *get*_transaction(), get*_burst(), get*_phase(), get*_cycle()* tasks. Refer to the individual master, slave or monitor BFM API for details.

# Access Transaction Record

Each BFM API has tasks that can access a complete or partially complete Transaction Record. The *set*()* and *get*()* tasks are used in a test program to set and get information from the transaction record.

**Note**

The *set*()* and *get*()* tasks are not explicitly described in each BFM API chapter. The simple rule for the task name is *set_* or *get_* followed by the name of the transaction field accessed. Refer to "Transaction Fields" on page 10 for transaction field name details.

## set*()

For example, to set the *WSTRB* write strobes signal for the first phase (beat) in the Transaction Record of a write transaction, the master test program would use the *set_write_strobes()* task, as shown in the code below.

```
write_trans.set_write_strobes(4'b0010, 0);
```

## get*()

For example, a slave BFM test program uses a received write address phase to get the *AWPROT* signal value from the Transaction Record, as shown in the slave BFM test program code below.

```
// Define a variable prot_value of type axi_transaction
axi_prot_e prot_value;

slave_trans = bfm.create_slave_transaction();

// Wait for a write address phase
bfm.get_write_addr_phase(slave_trans);

... …

// Get the AWPROT signal value of the slave transaction
prot_value = bfm.get_prot(slave_trans);
```

**Note**

The above test program code segments are for AXI3 BFMs. For AXI4 BFMs, substitute the *axi_transaction* type definition with *axi4_transaction* and *axi_prot_e* with *axi4_prot_e*.

# Operational Transaction Fields

Operational transaction fields control the way a transaction is executed onto the protocol signals. They also indicate when a data phase (beat) or transaction is complete.

## Automatic Generation of Byte Lane Strobes

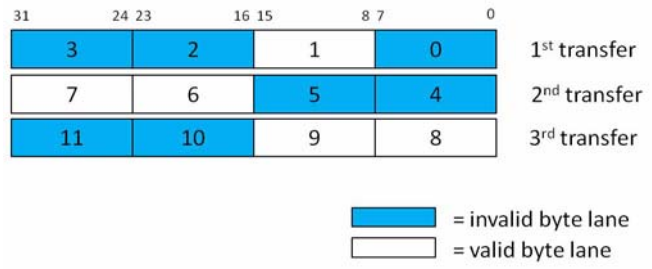
The master BFM permits unaligned and narrow write transfers by using byte lane strobe (*WSTRB)* signals to indicate which byte lanes contain valid data per data phase (beat).

When you create a write transaction in your master BFM test program, the *write_strobes* variable is available to store the write strobe values for each write data phase (beat) in the transaction. To assist you in creating the correct byte lane strobes, automatic correction of any previously set *write_strobes* is performed by default during execution of the write transaction, or write data phase (beat). You can disable this default behavior by setting the operational transaction field *gen_write_strobes = 0,* which allows any previously set *write_strobes* to pass through uncorrected onto the protocol *WSTRB* signals. In this mode, with the automatic correction disabled, you are responsible for setting the correct *write_strobes* for the whole transaction.

The automatic correction algorithm performs a bit-wise AND operation on any previously set *write_strobes*. To do the corrections, the correction algorithm uses the equations described in the AMBA AXI Protocol Specification, section A3.4.1 that define valid write data byte lanes for legal protocol. Therefore, if you require automatic generation of all *write_strobes*, before the write transaction executes, you must set all *write_strobes* to 1, indicating that all bytes lanes initially contain valid write data prior to the execution of the write transaction. Automatic correction then sets the relevant *write_strobes* to 0 to produce legal protocol *WSTRB* signals.

For example, Figure 1-2 below shows byte lanes that can contain valid data for a write transaction with a starting address = 0x01, size = 0b001 (2 bytes), type = INCR, and the length = 0b0010 (3 beats) for a 32-bit write data bus.

**Figure 1-2. Valid Data on Byte Lanes During a Write Transaction**



In the above example, if you set all *write_strobes[]* array elements to 1 before executing the write transaction, automatic correction produces the following results while the transaction executes.

| | Prior to Execution | | During Execution |
|---|---|---|---|
| 1st data phase | write_strobes[0]=0b1111 | -> | write_strobes[0]=0b0010 |
| 2nd data phase | write_strobes[1]=0b1111 | -> | write_strobes[1]=0b1100 |
| 3rd data phase | write_strobes[2]=0b1111 | -> | write_strobes[2]=0b0011 |

If you randomly set all *write_strobes[]* array elements to 0 or 1, before executing the write transaction, automatic correction corrects **only** those *write_strobes[]* array elements that were previously set to 1, as shown below.

| | Prior to Execution | | During Execution |
|---|---|---|---|
| 1st data phase | write_strobes[0]=0b1010 | -> | write_strobes[0]=0b0010 |
| 2nd data phase | write_strobes[1]=0b1010 | -> | write_strobes[1]=0b1000 |
| 3rd data phase | write_strobes[2]=0b1010 | -> | write_strobes[2]=0b0010 |

**Note**

To automatically generate all *WSTRB* signals for a write transaction, set all *write_strobes[]* array elements to 1 before executing the write transaction or write data burst.

## Operation Mode

By default, each read or write transaction performs a blocking operation which prevents a following transaction from starting until the current active transaction completes.

You can configure this behavior to be nonblocking by setting the *operation_mode* transaction field to the enumerate type value *AXI_TRANSACTION_NON_BLOCKING* instead of the default *AXI_TRANSACTION_BLOCKING*.

For example, in a master BFM test program you create a transaction by calling the *create_read_transaction()* or *create_write_transaction()* tasks which creates a transaction record. Before executing the transaction record, the *operation_mode* can be changed as follows:

```
// Create a write transaction to create a transaction record
trans = bfm.create_write_transaction(1);

// Change operation_mode to be nonblocking in the transaction record
trans.operation_mode(AXI_TRANSACTION_NON_BLOCKING);
```

**Note**

The above test program code segments are for AXI3 BFMs. Substitute the *AXI_TRANSACTION_NON_BLOCKING* enumeration with *AXI4_TRANSACTION_NON_BLOCKING* for AXI4 BFMs.

# Channel Handshake Delay

Each of the five protocol channels have **VALID* and **READY* handshake signals that control the rate at which information is transferred between a master and slave. The API to control these handshake signals differs between the AXI3 BFMs and AXI4 BFMs. Refer to the AXI3 BFM Handshake Delay and AXI3 BFM Delay Mode for details of the AXI3 BFM API, and AXI4 BFM Handshake Delay for details of the AXI4 BFM API.

## AXI3 BFM Handshake Delay

The delay between the **VALID* and **READY* handshake signals for each of the five protocol channels can be configured. The delay can be defined per phase (beat) basis for a particular transaction, measured from the positive edge of *ACLK* when **VALID* is asserted. The delay can also be set from the completion of a previous transaction phase (**VALID* and **READY* both asserted).

## AXI3 BFM Handshake Signal Delay Transaction Fields

The transaction record contains transaction fields to configure the desired handshake delay pattern for a particular transaction phase on any of the five protocol channels. The master BFM configures the **VALID* and **READY* signal delays that it asserts, and the slave BFM configures the **VALID* and **READY* signal delays that it asserts. Table 1-2 specifies which operational delay transaction fields are configured by the master and slave BFMs.

**Table 1-2. Handshake Signal Delay Transaction Fields**

| Signal | Operational Transaction Field | Configuration BFM |
|---|---|---|
| AWVALID | address_valid_delay | Master |
| AWREADY | address_ready_delay | Slave |
| WVALID | data_valid_delay | Master |
| WREADY | data_ready_delay | Slave |
| BVALID | write_response_valid_delay | Slave |
| BREADY | write_response_ready_delay | Master |
| ARVALID | address_valid_delay | Master |
| ARREADY | address_ready_delay | Slave |
| RVALID | data_valid_delay | Slave |
| RREADY | data_ready_delay | Master |

**Note**

The data channel handshake signal transaction fields (*data_valid_delay[]* and *data_ready_delay[]*) are defined as arrays so that the **VALID* to **READY* delay can be configured on a per data phase (beat) basis in a transaction.

## AXI4 BFM Handshake Delay

The delay between the **VALID* and **READY* handshake signals for each of the five protocol channels is controlled in a BFM test program using *execute_*_ready()*, *get_*_ready(),* and *get_*_cycle()* tasks. The *execute_*_ready()* tasks place a value onto the **READY* signals and the *get_*_ready()* tasks retrieve a value from the **READY* signals. The *get_*_cycle()* tasks wait for a **VALID* signal to be asserted and are used to insert a delay between the **VALID* and **READY* signals in the BFM test program.

For example, the master BFM test program code below inserts a specified delay between the read channel *RVALID* and *RREADY* handshake signals using the *execute_read_data_ready()* and *get_read_data_cycle()* tasks.

```
// Set the RREADY signal to '0' so that it is nonblocking
fork
   bfm.execute_read_data_ready(1'b0);
join_none

// Wait until the RVALID signal is asserted and then wait_on the specified
// number of ACLK cycles
bfm.get_read_data_cycle;
repeat(5) bfm.wait_on(AXI4_CLOCK_POSEDGE);

// Set the RREADY signal to '1' so that it blocks for an ACLK cycle
bfm.execute_read_data_ready(1'b1);
```

## AXI4 BFM **VALID* Signal Delay Transaction Fields

The transaction record contains a **_valid_delay* transaction field for each of the five protocol channels to configure the delay value prior to the assertion of the **VALID* signal for the channel. The master BFM holds the delay configuration for the **VALID* signals that it asserts, and the slave BFM holds the delay configuration for the **VALID* signals that it asserts. Table 1-3 below specifies which **_valid_delay* fields are configured by the master and slave BFMs.

**Table 1-3. Master and Slave*_valid_delay Configuration Fields**

| Signal | Operational Transaction Field | Configuration BFM |
|---|---|---|
| AWVALID | address_valid_delay | Master |
| WVALID | data_valid_delay | Master |
| BVALID | write_response_valid_delay | Slave |
| ARVALID | address_valid_delay | Master |
| RVALID | data_valid_delay | Slave |

**Note**

In the transaction record, the data channel handshake signal transaction field (*data_valid_delay[]*) is defined as an array, which allows you to configure the **VALID* delay on a per data phase (beat) basis in a transaction.

## AXI4 BFM **READY* Handshake Signal Delay Transaction Fields

The transaction record contains a **_ready_delay* transaction field for each of the five protocol channels to store the delay value that occurred between the assertion of the **VALID* and **READY* handshake signals for the channel. Table 1-4 specifies the **_ready_delay* field corresponding to the **READY* signal delay.

**Table 1-4. Master &Slave **_ready_delay* Transaction Fields**

| Signal | Operational Transaction Field |
|---|---|
| AWREADY | address_ready_delay |
| WREADY | data_ready_delay |
| BREADY | write_response_ready_delay |
| ARREADY | address_ready_delay |
| RREADY | data_ready_delay |

**Note**

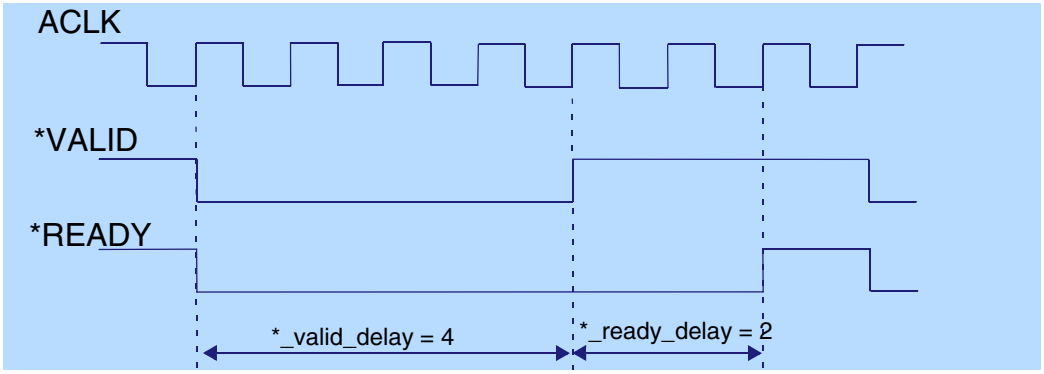
In the transaction record, the data channel handshake signal transaction field (*data_ready_delay[]*) is defined as an array so that the **READY* delay can be recorded on a per data phase (beat) basis in a transaction.

# AXI3 BFM Delay Mode

The delay mode can be configured on a per transaction basis using the *delay_mode* operational transaction field. This transaction field can be configured to the enumerated type values of *AXI_VALID2READY* (default) or *AXI_TRANS2READY*.

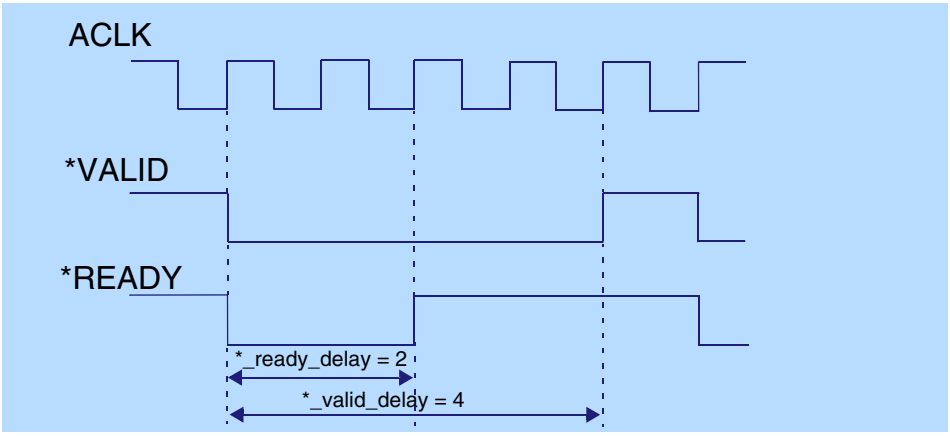
The default configuration (*delay_mode* = *AXI_VALID2READY*) corresponds to the delay measured from the positive edge of *ACLK* when **VALID* is asserted in a transaction. Figure 1-3 demonstrates how to achieve a **VALID* asserted before **READY* handshake.

**Figure 1-3. Operational Transaction Field delay_mode = AXI_VALID2READY**




The other configuration (*delay_mode* = *AXI_TRANS2READY*) corresponds to the delay measured from the completion of a previous transaction phase (**VALID* and **READY* both asserted). Figure 1-4 demonstrates how to achieve a **READY* before **VALID* handshake.

**Figure 1-4. Operational Transaction Field delay_mode = AXI_TRANS2READY**



## Data Beat Done

There is a *data_beat_done* transaction field for each transaction, defined as an array, to indicate when each data phase (beat) has completed. Each element of the *data_beat_done* array is set to 1 when each data phase (beat) has completed in a data burst.

You call the *get_read_data_phase()* task in the master BFM test program to investigate how many beats of a read data burst have completed by analyzing how many elements of the *data_beat_done* array have been set to 1. Similarly, the *get_write_data_phase()* task can be called in the slave BFM test program to analyze a write data burst.

## Transaction Done

The *transaction_done* field in each transaction indicates when the transaction is complete.

In a master BFM test program, you call the *get_read_data_burst()* task to investigate whether a read transaction is complete, and the *get_write_response_phase()* to investigate whether a write transaction is complete.

# Chapter 2
# The AXI Transaction

This section describes AXI transactions in the Mentor Verification IP Altera Edition (Mentor VIP AE).

## What is a Transaction?

A transaction for Mentor VIP AE represents an instance of information that is transferred between a master and a slave peripheral, and that adheres to the protocol used to transfer the information. For example, a write transaction transfers an address phase, a data burst, followed by a response phase. A subsequent instance of transferred information requires a new and unique transaction.

Each transaction has a dynamic Transaction Record that exists for the life of the transaction. The life of a transaction record starts when it is created and ends when the transaction completes. The transaction record is automatically discarded when the transaction ends. When created, a transaction contains *transaction fields* that you set to define two transaction aspects: the *protocol fields* that are transferred over the protocol signals and *operation fields* that determine how the information is transferred and when the transfer is complete. For example, a write transaction record holds the *protection* information in the *prot* protocol field, the value of this field is transferred over the *AWPROT* protocol signals during an address phase. A write transaction also has a *transaction_done* operation field that indicates when the transaction is complete; this field is not transferred over the protocol signals. These two types of transaction fields, *protocol* and *operation*, establish a dynamic record during the life of the transaction.

In addition to transaction fields, you specify *arguments* to tasks, functions, and procedures that permit you to create, set, and get the dynamic transaction record during a transaction's lifetime. Each BFM has an API that controls how you access the BFM transaction record. How you access the record also depends on the source code language, whether it is VHDL or SystemVerilog. Methods for accessing transactions based on the language you use are explained in detail in the relevant chapters of this user guide.

# An AXI Transaction

**Note**

The following description of an AXI transaction is applicable to AXI3 and AXI4 protocols.

A complete read/write transaction transfers information between a master and a slave peripheral. Transaction fields, described in the previous section, What is a Transaction? determine what is transferred and how information is transferred. During the lifetime of a transaction, the roles of the master and slave ensure that a transaction completes successfully and that transferred information adheres to the protocol specification. Information flows in both directions during a transaction with the master initiating the transaction and the slave reporting back to the master that the transaction has completed.

An AXI protocol uses five channels; three write channels and two read channels, to transfer protocol information. Each of these channels has a pair of handshake signals, **VALID* and **READY*, that indicates valid information on a channel and the acceptance of the information from the channel.

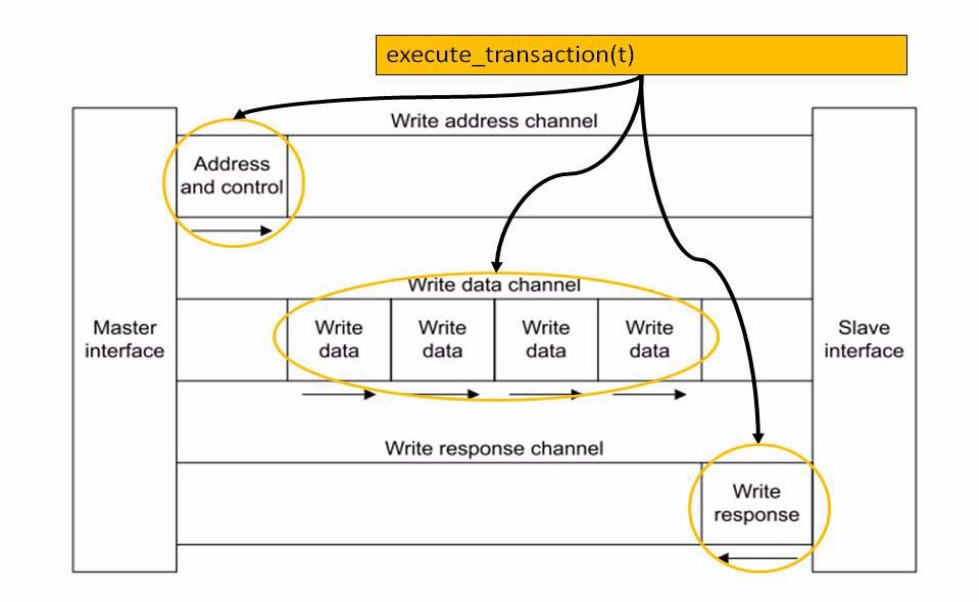
## AXI Write Transaction Master and Slave Roles

**Note**

The following description of a write transaction references SystemVerilog BFM API tasks. There are equivalent VHDL BFM API procedures that perform the same functionality.

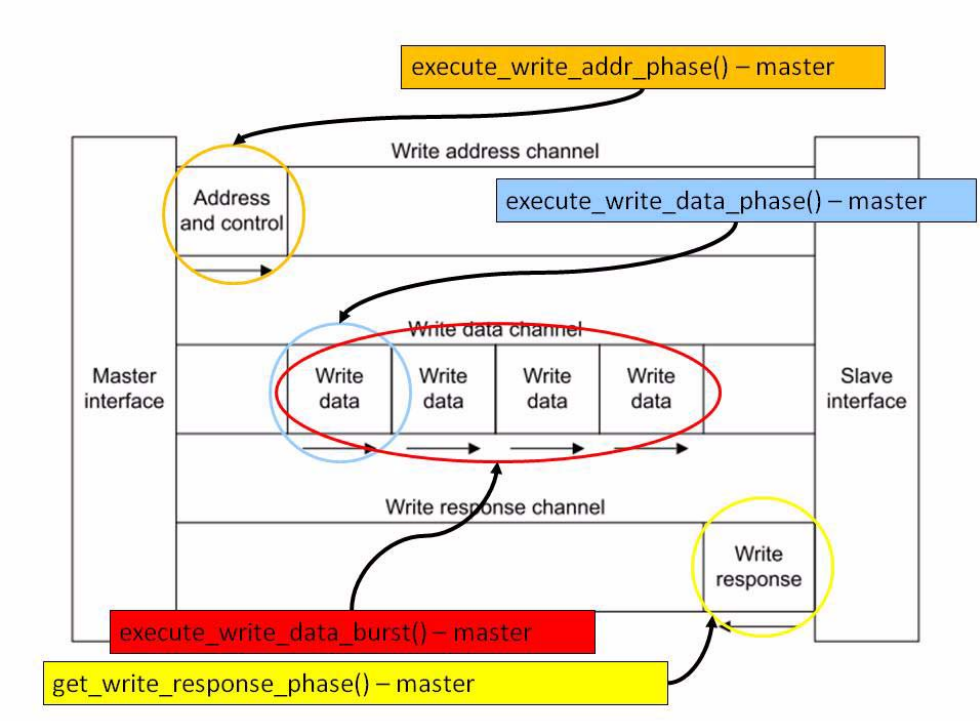
For a write transaction, the master calls the *create_write_transaction()* task to define the information to be transferred and then calls the *execute_transaction()* task to initiate the transfer of information as Figure 2-1 illustrates.

**Figure 2-1. Execute WriteTransaction**




The *execute_transaction()* task results in the master calling the *execute_write_addr_phase()* task followed by the *execute_write_data_burst()* task. The *execute_write_data_burst()* calls the *execute_write_data_phase()* task for each phase (beat) of the burst defined by a *burst_length* transaction field as illustrated in Figure 2-2.

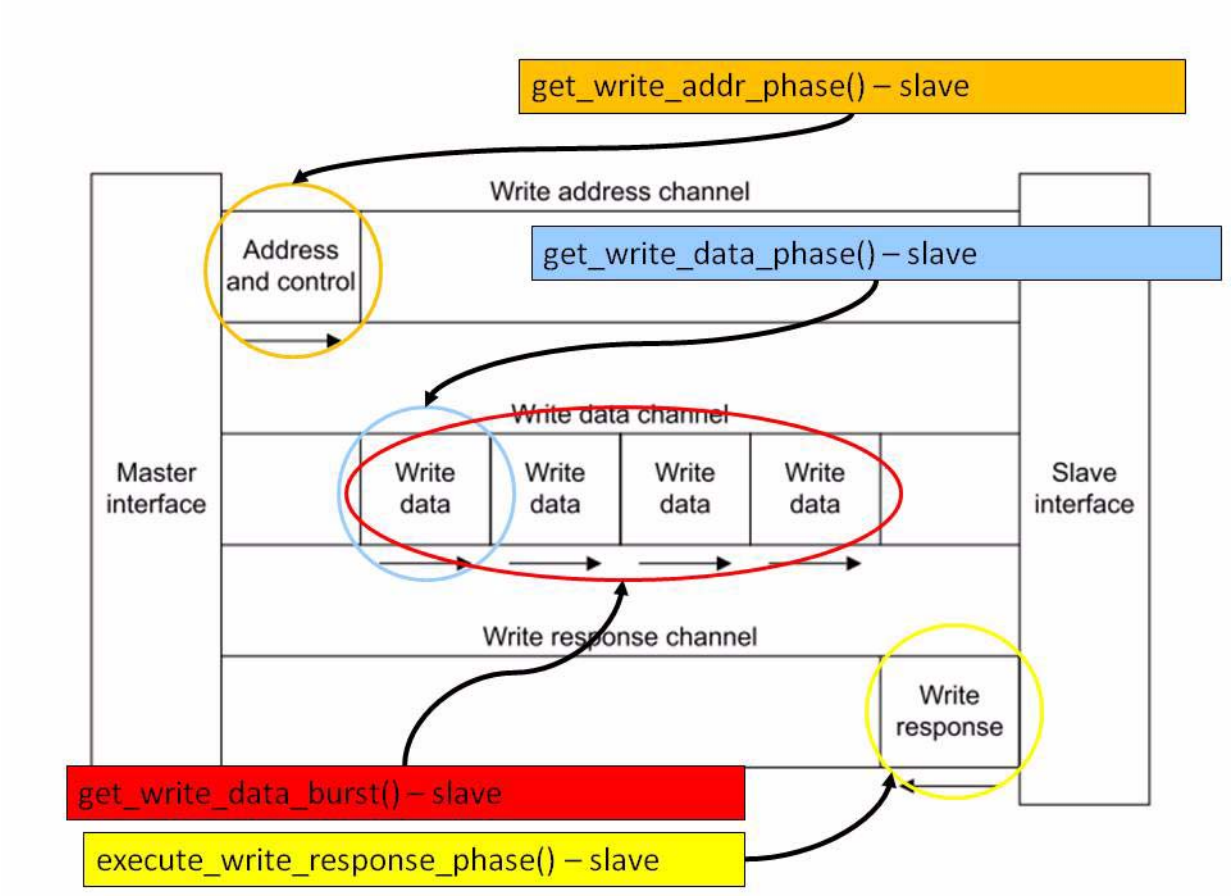
**Figure 2-2. Master Write Transaction Phases**



The master then calls the *get_write_response_phase()* task to receive the response from the slave and to complete its role in the write transaction.

The slave also creates a transaction by calling the *create_slave_transaction()* task to accept the transfer of information from the master. The address phase and data burst are received by the slave calling the *get_write_addr_phase()* task, followed by the *get_write_data_burst()* task. The *get_write_data_burst()* calls the *get_write_data_phase()* task for each phase (beat) of the burst defined by a *burst_length* transaction field, as illustrated in Figure 2-3.

**Figure 2-3. Slave Write Transaction Phases**




The slave then executes a write response phase by calling the *execute_write_response_phase()* task and completes its role in the write transaction.

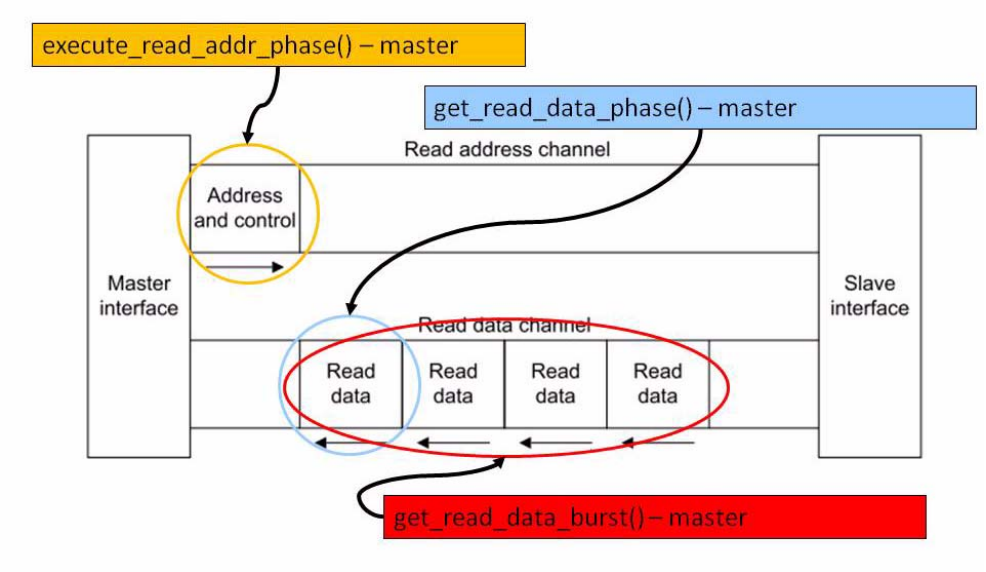
# AXI Read Transaction Master and Slave Roles

**Note**

The following description of a read transaction references the SystemVerilog BFM API tasks. There are equivalent VHDL BFM API procedures that perform the same functionality.

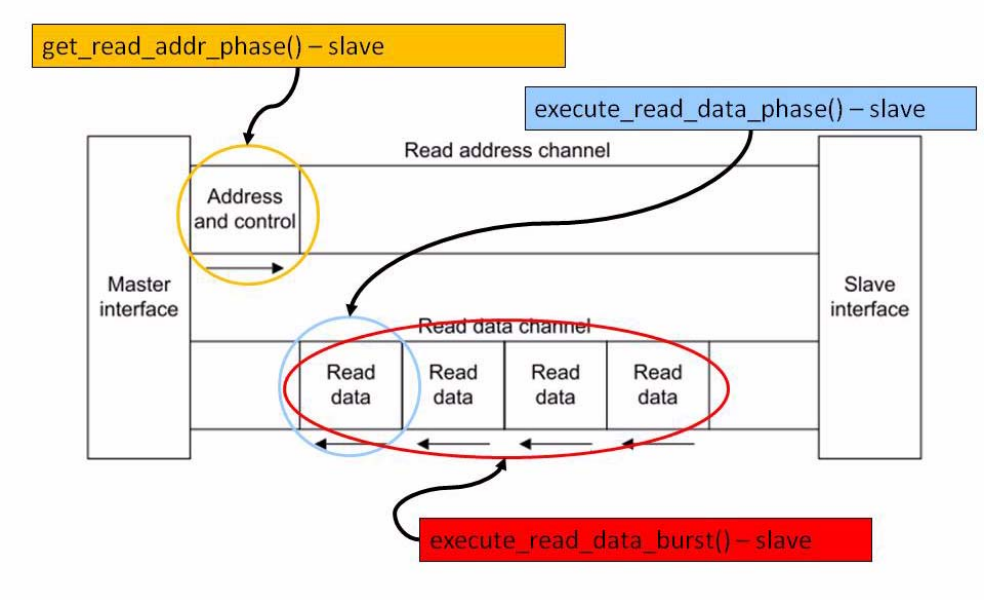
A read transaction is similar to a write transaction. The master initiates the read by calling the *create_read_transaction()* and *execute_transaction()* tasks. The *execute_transaction()* calls the the *execute_read_addr_phase()* task followed by the *get_read_data_burst()* task. The *get_read_data_burst()* calls the *get_read_data_phase()* task for each phase (beat) of the burst defined by a *burst_length* transaction field, as illustrated in Figure 2-4.

**Figure 2-4. Master Read Transaction Phases**




The slave creates a read transaction by calling the *create_slave_transaction()* task to accept the transfer of read information from the master. The slave accepts the address phase by calling the *get_read_addr_phase()* task, and then executes the data burst by calling the *execute_read_data_burst()* task. The *execute_read_data_burst()* calls the *execute_read_data_phase()* task for each phase (beat) of the burst defined by the *burst_length* transaction field, as illustrated in Figure 2-5.

**Figure 2-5. Slave Read Transaction Phases**



# Chapter 3
# SystemVerilog AXI3 and AXI4 Master BFMs

This section provides information about the SystemVerilog AXI3 and AXI4 master BFMs. Each BFM has an API that contains tasks and functions to configure the BFM and to access the dynamic Transaction Record during the lifetime of the transaction.

**Note**

Due to AXI3 protocol specification changes, for some BFM tasks, you reference the AXI3 BFM by specifying AXI instead of AXI3.

## Master BFM Protocol Support

The AXI3 master BFM supports the AMBA AXI3 protocol with restrictions described in "Protocol Restrictions" on page 1. In addition to the standard protocol, it supports user sideband signals *AWUSER* and *ARUSER*.

The AXI4 master BFM supports the AMBA AXI4 protocol with restrictions described in "Protocol Restrictions" on page 1.

## Master Timing and Events

For detailed timing diagrams of the protocol bus activity, refer to the relevant AMBA AXI protocol specification chapter, which you can use to reference details of the following master BFM API timing and events.

The AMBA AXI protocol specification does not define any timescale or clock period with signal events sampled and driven at rising *ACLK* edges. Therefore, the master BFM does not contain any timescale, timeunit, or timeprecision declarations with the signal setup and hold times specified in units of simulator time-steps.

The simulator time-step resolves to the smallest of all the time-precision declarations in the testbench and design IP as a result of these directives, declarations, options, or initialization files:

- `timescale directives in design elements.
- timeprecision declarations in design elements.
- compiler command-line options.
- simulation command-line options.
- local or site-wide simulator initialization files.

If there is no timescale directive, the default time unit and time precision are tool specific. The recommended practice is to use timeunit and timeprecision declarations. Refer to the SystemVerilog LRM section 3.14 for details.

# Master BFM Configuration

A master BFM supports the full range of signals defined for the AMBA AXI protocol specification. It has parameters that configure the widths of the address, data and ID signals, and transaction fields to specify timeout factors, slave exclusive support, setup and hold times, etc.

The address, data and ID signal widths can be changed from their default settings by assigning them new values, usually in the top-level module of the testbench. These new values are then passed to the master BFM using a parameter port list of the master BFM module. For example, the code extract below shows the AXI3 master BFM with the address and the data and ID signal widths defined in *module top()* and passed to the master BFM *mgc_axi_master* parameter port list:

```
module top ();

   parameter AXI_ADDRESS_WIDTH = 24;
   parameter AXI_RDATA_WIDTH = 16;
   parameter AXI_WDATA_WIDTH = 16;
   parameter AXI_ID_WIDTH = 4;

   mgc_axi_master #(AXI_ADDRESS_WIDTH, AXI_RDATA_WIDTH, AXI_WDATA_WIDTH,
AXI_ID_WIDTH) bfm_master(....);
```

**Note**

In the above code extract, the *mgc_axi_master* is the AXI3 master BFM interface.

The following table lists parameter names for the address, data and ID signals, and their default values.

**Table 3-1. Master BFM Signal Width Parameters**

| **Signal Width Parameter** (Note: ** = AXI or AXI4) | **Description** |
|---|---|
| **_ADDRESS_WIDTH | Address signal width in bits. This applies to the *ARADDR* and *AWADDR* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 64. |
| **_RDATA_WIDTH | Read data signal width in bits. This applies to the *RDATA* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 1024. |
| **_WDATA_WIDTH | Write data signal width in bits. This applies to the *WDATA* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 1024. |
| **_ID_WIDTH | ID signal width in bits. This applies to the *RID* and *WID* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 18. |
| AXI4_USER_WIDTH | (AXI4) User data signal width in bits. This applies to the *ARUSER*, *AWUSER*, *RUSER*, *WUSER* and *BUSER* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 8. |
| AXI4_REGION_MAP_SIZE | (AXI4) Region signal width in bits. This applies to the *ARREGION* and *AWREGION* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 16. |

A master BFM has configuration fields that you can set with the *set_config()* function to configure timeout factors, slave exclusive support, and setup and hold times, etc. You can also get the value of a configuration field using the *get_config()* function. The full list of configuration fields is described in Table 3-2 below.

**Table 3-2. Master BFM Configuration**

| **Configuration Field** (Note: ** = AXI or AXI4) | **Description** |
|---|---|
| **Timing Variables** | |
| **_CONFIG_SETUP_TIME | The setup-time prior to the active edge of *ACLK*, in units of simulator time-steps for all signals.[1] Default: 0. |
| **_CONFIG_HOLD_TIME | The hold-time after the active edge of *ACLK*, in units of simulator time-steps for all signals.[1] Default: 0. |
| **_CONFIG_BURST_TIMEOUT_FACTOR | The maximum delay between the individual phases of a read/write transaction in clock cycles. Default: 10000. |

**Table 3-2. Master BFM Configuration**

| Configuration Field | Description |
|---|---|
| **Timing Variables** | |
| AXI4_CONFIG_MAX_LATENCY_AWVALID_ ASSERTION_TO_AWREADY | (AXI4) The maximum timeout duration from the assertion of *AWVALID* to the assertion of *AWREADY* in clock periods (default 10000). |
| AXI4_CONFIG_MAX_LATENCY_ARVALID_ ASSERTION_TO_ARREADY | (AXI4) The maximum timeout duration from the assertion of *ARVALID* to the assertion of *ARREADY* in clock periods (default 10000). |
| AXI4_CONFIG_MAX_LATENCY_RVALID_ ASSERTION_TO_RREADY | (AXI4) The maximum timeout duration from the assertion of *RVALID* to the assertion of *RREADY* in clock periods (default 10000). |
| AXI4_CONFIG_MAX_LATENCY_BVALID_ ASSERTION_TO_BREADY | (AXI4) The maximum timeout duration from the assertion of *BVALID* to the assertion of *BREADY* in clock periods (default 10000). |
| AXI4_CONFIG_MAX_LATENCY_WVALID_ ASSERTION_TO_WREADY | (AXI4) The maximum timeout duration from the assertion of *WVALID* to the assertion of *WREADY* in clock periods (default 10000). |
| **Master Attributes** | |
| AXI_CONFIG_WRITE_CTRL_TO_DATA_MINTIME | (AXI3) The minimum delay from the start of a write control (address) phase to the start of the first write data phase (beat) in clock cycles. Default: 1. |
| AXI_CONFIG_MASTER_WRITE_DELAY | (AXI3) The master BFM applies the AXI_CONFIG_WRITE_CTRL_TO_ DATA_MINTIME value set.<br>0 = true (default)<br>1 = false |
| AXI_CONFIG_MASTER_DEFAULT_UNDER_RESET | (AXI3) The master BFM drives the *ARVALID*, *AWVALID* and *WVALID* signals low during reset:<br>0 = false (default)<br>1 = true |
| AXI4_CONFIG_ENABLE_QOS | (AXI4) The master participates in the Quality-of-Service (qos) scheme. If a master does not participate, the *AWQOS/ARQOS* value used in write/read transactions must be b0000. |

**Table 3-2. Master BFM Configuration**

| Configuration Field<br>(Note: ** = AXI or AXI4) | Description |
|---|---|
| **Slave Attributes** | |
| **_CONFIG_SUPPORT_EXCLUSIVE_ACCESS | Configures the support for an exclusive slave. If enabled the BFM will expect an *EXOKAY* response to a successful exclusive transaction. If disabled the BFM will expect an *OKAY* response to an exclusive transaction. Refer to the AMBA AXI protocol specification for more details.<br>0 = disabled<br>1 = enabled (default) |
| AXI_CONFIG_SLAVE_DEFAULT_UNDER_RESET | (AXI3) The slave BFM drives the *BVALID* and *RVALID* signals low during reset. Refer to the AMBA AXI Protocol specification for more details.<br>0 = false (default)<br>1 = true |
| AXI4_CONFIG_SLAVE_START_ADDR | (AXI4) Configures the start address map for the slave. |
| AXI4_CONFIG_SLAVE_END_ADDR | (AXI4) Configures the end address map for the slave. |
| AXI4_CONFIG_READ_DATA_REORDERING_DEPTH | (AXI4) The slave read reordering depth. Refer to the AMBA AXI Protocol specification for more details. Default: 1. |
| **Error Detection** | |
| **_CONFIG_ENABLE_ALL_ASSERTIONS | Global enable/disable of all assertion checks in the BFM.<br>0 = disabled<br>1 = enabled (default) |

[1.] Refer to Master Timing and Events for details of simulator time-steps.

# Master Assertions

Each master BFM performs protocol error checking using the built-in assertions.

**Note**
The built-in BFM assertions are independent of programming language and simulator.

# AXI3 Assertion Configuration

By default, all built-in assertions are enabled in the master BFM. To globally disable them in the master BFM, use the *set_config()* command as the following example illustrates:

```
set_config(AXI_CONFIG_ENABLE_ALL_ASSERTIONS,0)
```

Alternatively, individual built-in assertions can be disabled by using a sequence of *get_config()* and *set_config()* commands on the respective assertion. For example, to disable assertion checking for the *AWLOCK* signal changing between the *AWVALID* and *AWREADY* handshake signals, use the following sequence of commands:

```
// Define a local bit vector to hold the value of the assertion bit vector
bit [255:0] config_assert_bitvector;

// Get the current value of the assertion bit vector
config_assert_bitvector = bfm.get_config(AXI_CONFIG_ENABLE_ASSERTION);

// Assign the AXI_LOCK_CHANGED_BEFORE_AWREADY assertion bit to 0
config_assert_bitvector[AXI_LOCK_CHANGED_BEFORE_AWREADY] = 0;

// Set the new value of the assertion bit vector
bfm.set_config(AXI_CONFIG_ENABLE_ASSERTION, config_assert_bitvector);
```

**Note**

Do not confuse the *AXI_CONFIG_ENABLE_ASSERTION* bit vector with the *AXI_CONFIG_ENABLE_ALL_ASSERTIONS* global enable/disable.

To re-enable the *AXI_LOCK_CHANGED_BEFORE_AWREADY* assertion, follow the above code sequence and assign the assertion in the *AXI_CONFIG_ENABLE_ASSERTION* bit vector to 1.

For a complete listing of AXI3 assertions, refer to "AXI3 Assertions" on page 641.

## AXI4 Assertion Configuration

By default, all built-in assertions are enabled in the master AXI4 BFM. To globally disable them in the master BFM, use the *set_config()* command as the following example illustrates:

```
set_config(AXI4_CONFIG_ENABLE_ALL_ASSERTIONS,0)
```

Alternatively, individual built-in assertions can be disabled by using a sequence of *get_config()* and *set_config()* commands on the respective assertion. For example, to disable assertion checking for the *AWLOCK* signal changing between the *AWVALID* and *AWREADY* handshake signals, use the following sequence of commands:

```
// Define a local bit vector to hold the value of the assertion bit vector
bit [255:0] config_assert_bitvector;

// Get the current value of the assertion bit vector
config_assert_bitvector = bfm.get_config(AXI4_CONFIG_ENABLE_ASSERTION);

// Assign the AXI4_LOCK_CHANGED_BEFORE_AWREADY assertion bit to 0
config_assert_bitvector[AXI4_LOCK_CHANGED_BEFORE_AWREADY] = 0;

// Set the new value of the assertion bit vector
bfm.set_config(AXI4_CONFIG_ENABLE_ASSERTION, config_assert_bitvector);
```

**Note**

Do not confuse the *AXI4_CONFIG_ENABLE_ASSERTION* bit vector with the *AXI4_CONFIG_ENABLE_ALL_ASSERTIONS* global enable/disable.

To re-enable the *AXI4_LOCK_CHANGED_BEFORE_AWREADY* assertion, follow the above code sequence and assign the assertion in the *AXI4_CONFIG_ENABLE_ASSERTION* bit vector to 1.

For a complete listing of AXI4 assertions, refer to "AXI4 Assertions" on page 654.

# SystemVerilog Master API

This section describes the SystemVerilog master API.

# set_config()

This function sets the configuration of the master BFM.

**Prototype**

```
// * = axi | axi4
function void set_config
(
   input *_config_e config_name,
   input *_max_bits_t config_val
);
```

**Arguments**

config_name

**(AXI3) Configuration name:**

AXI_CONFIG_SETUP_TIME
AXI_CONFIG_HOLD_TIME
AXI_CONFIG_MAX_TRANSACTION_TIME_FACTOR
AXI_CONFIG_TIMEOUT_MAX_DATA_TRANSFER
AXI_CONFIG_BURST_TIMEOUT_FACTOR
AXI_CONFIG_WRITE_CTRL_TO_DATA_MINTIME
AXI_CONFIG_MASTER_WRITE_DELAY
AXI_CONFIG_MASTER_DEFAULT_UNDER_RESET
AXI_CONFIG_SLAVE_DEFAULT_UNDER_RESET
AXI_CONFIG_ENABLE_ALL_ASSERTIONS
AXI_CONFIG_MASTER_ERROR_POSITION
AXI_CONFIG_SUPPORT_EXCLUSIVE_ACCESS

**(AXI4) Configuration name:**

AXI4_CONFIG_SETUP_TIME
AXI4_CONFIG_HOLD_TIME
AXI4_CONFIG_BURST_TIMEOUT_FACTOR
AXI4_CONFIG_ENABLE_RLAST
AXI4_CONFIG_ENABLE_SLAVE_EXCLUSIVE
AXI4_CONFIG_ENABLE_ALL_ASSERTIONS
AXI4_CONFIG_ENABLE_ASSERTION
AXI4_CONFIG_MAX_LATENCY_AWVALID_ASSERTION_TO_AWREADY
AXI4_CONFIG_MAX_LATENCY_ARVALID_ASSERTION_TO_ARREADY
AXI4_CONFIG_MAX_LATENCY_RVALID_ASSERTION_TO_RREADY
AXI4_CONFIG_MAX_LATENCY_BVALID_ASSERTION_TO_BREADY
AXI4_CONFIG_MAX_LATENCY_WVALID_ASSERTION_TO_WREADY
AXI4_CONFIG_ENABLE_QOS
AXI4_CONFIG_READ_DATA_REORDERING_DEPTH
AXI4_CONFIG_SLAVE_START_ADDR
AXI4_CONFIG_SLAVE_END_ADDR

See "Master BFM Configuration" on page 32 for descriptions and valid values.

**Returns**

None

## AXI3 Example

```
set_config(AXI_CONFIG_SUPPORT_EXCLUSIVE_ACCESS, 1);
set_config(AXI_CONFIG_BURST_TIMEOUT_FACTOR, 1000);
```

## AXI4 Example

```
set_config(AXI4_CONFIG_ENABLE_SLAVE_EXCLUSIVE, 1);
set_config(AXI4_CONFIG_BURST_TIMEOUT_FACTOR, 1000);
```

# get_config()

This function gets the configuration of the master BFM.

**Prototype**

```
// * = axi | axi4
function void get_config
(
   input *_config_e config_name,
);
```

**Arguments**

config_name

**(AXI3) Configuration name:**
- AXI_CONFIG_SETUP_TIME
- AXI_CONFIG_HOLD_TIME
- AXI_CONFIG_MAX_TRANSACTION_TIME_FACTOR
- AXI_CONFIG_TIMEOUT_MAX_DATA_TRANSFER
- AXI_CONFIG_BURST_TIMEOUT_FACTOR
- AXI_CONFIG_WRITE_CTRL_TO_DATA_MINTIME
- AXI_CONFIG_MASTER_WRITE_DELAY
- AXI_CONFIG_MASTER_DEFAULT_UNDER_RESET
- AXI_CONFIG_SLAVE_DEFAULT_UNDER_RESET
- AXI_CONFIG_ENABLE_ALL_ASSERTIONS
- AXI_CONFIG_MASTER_ERROR_POSITION
- AXI_CONFIG_SUPPORT_EXCLUSIVE_ACCESS

**(AXI4) Configuration name:**
- AXI4_CONFIG_SETUP_TIME
- AXI4_CONFIG_HOLD_TIME
- AXI4_CONFIG_BURST_TIMEOUT_FACTOR
- AXI4_CONFIG_ENABLE_RLAST
- AXI4_CONFIG_ENABLE_SLAVE_EXCLUSIVE
- AXI4_CONFIG_ENABLE_ALL_ASSERTIONS
- AXI4_CONFIG_ENABLE_ASSERTION
- AXI4_CONFIG_MAX_LATENCY_AWVALID_ASSERTION_TO_AWREADY
- AXI4_CONFIG_MAX_LATENCY_ARVALID_ASSERTION_TO_ARREADY
- AXI4_CONFIG_MAX_LATENCY_RVALID_ASSERTION_TO_RREADY
- AXI4_CONFIG_MAX_LATENCY_BVALID_ASSERTION_TO_BREADY
- AXI4_CONFIG_MAX_LATENCY_WVALID_ASSERTION_TO_WREADY
- AXI4_CONFIG_ENABLE_QOS
- AXI4_CONFIG_READ_DATA_REORDERING_DEPTH
- AXI4_CONFIG_SLAVE_START_ADDR
- AXI4_CONFIG_SLAVE_END_ADDR

**Returns**

config_val

See "Master BFM Configuration" on page 32 for descriptions and valid values.

## AXI3 Example

```
get_config(AXI_CONFIG_SUPPORT_EXCLUSIVE_ACCESS);
get_config(AXI_CONFIG_BURST_TIMEOUT_FACTOR);
```

## AXI4 Example

```
get_config(AXI4_CONFIG_ENABLE_SLAVE_EXCLUSIVE);
get_config(AXI4_CONFIG_BURST_TIMEOUT_FACTOR);
```

# create_write_transaction()

This nonblocking function creates a write transaction with a start address *addr* and optional *burst_length* arguments. All other transaction fields default to legal protocol values, unless previously assigned a value. It returns with the **_transaction* record.

**Prototype**

```
// * = axi | axi4
// ** = AXI | AXI4
function automatic *_transaction create_write_transaction
(
    input bit [((**_ADDRESS_WIDTH) - 1):0]  addr,
    bit [3:0] burst_length = 0 // optional
);
```

**Arguments**

| | |
|---|---|
| addr | Start address |
| burst_length | (Optional) Burst length. Default: 0. |

**Protocol Transaction Fields**

| | |
|---|---|
| size | Burst size. Default: width of bus:<br>**_BYTES_1;<br>**_BYTES_2;<br>**_BYTES_4;<br>**_BYTES_8;<br>**_BYTES_16;<br>**_BYTES_32;<br>**_BYTES_64;<br>**_BYTES_128; |
| burst | Burst type:<br>**_FIXED;<br>**_INCR; (default)<br>**_WRAP;<br>**_BURST_RSVD; |
| lock | Burst lock:<br>**_NORMAL; (default)<br>**_EXCLUSIVE;<br>(AXI3) AXI_LOCKED;<br>(AXI3) AXI_LOCK_RSVD; |
| cache | (AXI3) Burst cache:<br>AXI_NONCACHE_NONBUF; (default)<br>AXI_BUF_ONLY;<br>AXI_CACHE_NOALLOC;<br>AXI_CACHE_BUF_NOALLOC;<br>AXI_CACHE_RSVD0;<br>AXI_CACHE_RSVD1;<br>AXI_CACHE_WTHROUGH_ALLOC_R_ONLY;<br>AXI_CACHE_WBACK_ALLOC_R_ONLY;<br>AXI_CACHE_RSVD2;<br>AXI_CACHE_RSVD3;<br>AXI_CACHE_WTHROUGH_ALLOC_W_ONLY;<br>AXI_CACHE_WBACK_ALLOC_W_ONLY;<br>AXI_CACHE_RSVD4;<br>AXI_CACHE_RSVD5;<br>AXI_CACHE_WTHROUGH_ALLOC_RW;<br>AXI_CACHE_WBACK_ALLOC_RW; |

| | | |
|---|---|---|
| | cache | (AXI4) Burst cache:<br>AXI4_NONMODIFIABLE_NONBUF; (default)<br>AXI4_BUF_ONLY;<br>AXI4_CACHE_NOALLOC;<br>AXI4_CACHE_2;<br>AXI4_CACHE_3;<br>AXI4_CACHE_RSVD4;<br>AXI4_CACHE_RSVD5;<br>AXI4_CACHE_6;<br>AXI4_CACHE_7;<br>AXI4_CACHE_RSVD8;<br>AXI4_CACHE_RSVD9;<br>AXI4_CACHE_10;<br>AXI4_CACHE_11;<br>AXI4_CACHE_RSVD12;<br>AXI4_CACHE_RSVD12;<br>AXI4_CACHE_14;<br>AXI4_CACHE_15; |
| | prot | Protection:<br>**_NORM_SEC_DATA; (default)<br>**_PRIV_SEC_DATA;<br>**_NORM_NONSEC_DATA;<br>**_PRIV_NONSEC_DATA;<br>**_NORM_SEC_INST;<br>**_PRIV_SEC_INST;<br>**_NORM_NONSEC_INST;<br>**_PRIV_NONSEC_INST; |
| | id | Burst ID |
| | data_words | Data words array. |
| | write_strobes | Write strobes array:<br>Each strobe 0 or 1. |
| | resp | Burst response:<br>**_OKAY;<br>**_EXOKAY;<br>**_SLVERR;<br>**_DECERR; |
| | region | (AXI4) Region identifier. |
| | qos | (AXI4) Quality-of-Service identifier. |
| | addr_user | Address channel user data. |
| | data_user | (AXI4) Data channel user data. |
| | resp_user | (AXI4) Response channel user data. |
| **Operational Transaction Fields** | gen_write_strobes | Generate write strobes flag:<br>0 = user supplied write strobes.<br>1 = auto-generated write strobes (default). |
| | operation_mode | Operation mode:<br>**_TRANSACTION_NON_BLOCKING;<br>**_TRANSACTION_BLOCKING; (default) |
| | delay_mode | (AXI3) Delay mode:<br>AXI_VALID2READY; (default)<br>AXI_TRANS2READY; |
| | write_data_mode | Write data mode:<br>**_DATA_AFTER_ADDRESS; (default)<br>**_DATA_WITH_ADDRESS; |

| | | |
|---|---|---|
| **Operational Transaction Fields** | address_valid_delay | Address channel *AWVALID* delay measured in *ACLK* cycles for this transaction (default = 0). |
| | data_valid_delay | Write data channel *WVALID* delay array measured in *ACLK* cycles for this transaction (default = 0 for all elements). |
| | write_response_ready_delay | Write response channel *BREADY* delay measured in *ACLK* cycles for this transaction (default = 0). |
| | data_beat_done | Write data channel beat *done* flag array for this transaction. |
| | transaction_done | Write transaction *done* flag for this transaction. |
| **Returns** | The **_transaction* record. | |

## AXI3 Example

```
// Create a write transaction with a data burst length of 3 (4 beats) to
// start address 16.
trans = bfm.create_write_transaction(16, 3);
trans.size = AXI_BYTES_4;
trans.data_words[0] = 'hACE0ACE1;
trans.data_words[1] = 'hACE2ACE3;
trans.data_words[2] = 'hACE4ACE5;
trans.data_words[3] = 'hACE6ACE7;
```

## AXI4 Example

```
// Create a write transaction with a data burst length of 3 to start
// address 16.
trans = bfm.create_write_transaction(16, 3);
trans.size = AXI4_BYTES_4;
trans.data_words[0] = 'hACE0ACE1;
trans.data_words[1] = 'hACE2ACE3;
trans.data_words[2] = 'hACE4ACE5;
trans.data_words[3] = 'hACE6ACE7;
```

# create_read_transaction()

This nonblocking function creates a read transaction with a start address *addr* and optional *burst_length* arguments. All other transaction fields default to legal AXI protocol values, unless previously assigned a value. It returns the **_transaction* record.

**Prototype**

```
// * = axi | axi4
// ** = AXI| AXI4
function automatic *_transaction create_read_transaction
(
    input bit [((**_ADDRESS_WIDTH) - 1):0]  addr,
    bit [3:0] burst_length = 0 //optional
);
```

**Arguments**

| | |
|---|---|
| addr | Start address |
| burst_length | (Optional) Burst length. Default: 0. |

**Protocol Transaction Fields**

| | |
|---|---|
| size | Burst size. Default: width of bus:<br>**_BYTES_1;<br>**_BYTES_2;<br>**_BYTES_4;<br>**_BYTES_8;<br>**_BYTES_16;<br>**_BYTES_32;<br>**_BYTES_64;<br>**_BYTES_128; |
| burst | Burst type:<br>**_FIXED;<br>**_INCR; (default)<br>**_WRAP;<br>**_BURST_RSVD; |
| lock | Burst lock:<br>**_NORMAL; (default)<br>**_EXCLUSIVE;<br>(AXI3) AXI_LOCKED;<br>(AXI3) AXI_LOCK_RSVD; |
| cache | (AXI4) Burst cache:<br>AXI4_NONMODIFIABLE_NONBUF; (default)<br>AXI4_BUF_ONLY;<br>AXI4_CACHE_NOALLOC;<br>AXI4_CACHE_2;<br>AXI4_CACHE_3;<br>AXI4_CACHE_RSVD4;<br>AXI4_CACHE_RSVD5;<br>AXI4_CACHE_6;<br>AXI4_CACHE_7;<br>AXI4_CACHE_RSVD8;<br>AXI4_CACHE_RSVD9;<br>AXI4_CACHE_10;<br>AXI4_CACHE_11;<br>AXI4_CACHE_RSVD12;<br>AXI4_CACHE_RSVD12;<br>AXI4_CACHE_14;<br>AXI4_CACHE_15; |

| | | |
|---|---|---|
| | prot | Protection:<br>**_NORM_SEC_DATA; (default)<br>**_PRIV_SEC_DATA;<br>**_NORM_NONSEC_DATA;<br>**_PRIV_NONSEC_DATA;<br>**_NORM_SEC_INST;<br>**_PRIV_SEC_INST;<br>**_NORM_NONSEC_INST;<br>**_PRIV_NONSEC_INST; |
| | | Burst ID |
| | data_words | Data words array. |
| | resp | Burst response:<br>**_OKAY;<br>**_EXOKAY;<br>**_SLVERR;<br>**_DECERR; |
| **Operational Transaction Fields** | operation_mode | Operation mode:<br>**_TRANSACTION_NON_BLOCKING;<br>**_TRANSACTION_BLOCKING; (default) |
| | delay_mode | (AXI3) Delay mode:<br>AXI_VALID2READY; (default)<br>AXI_TRANS2READY; |
| | address_valid_delay | Address channel *ARVALID* delay measured in *ACLK* cycles for this transaction (default = 0). |
| | data_ready_delay | Read data channel *RREADY* delay array measured in *ACLK* cycles for this transaction (default = 0 for all elements). |
| | data_beat_done | Write data channel beat *done* flag array for this transaction. |
| | transaction_done | Read transaction *done* flag for this transaction. |
| **Returns** | *_transaction | The transaction record: |

## AXI3 Example

```
// Create a read data burst length of 3 (4 beats) to start address 16.
trans = bfm.create_read_transaction(16, 3);
trans.size = AXI_BYTES_4;
```

## AXI4 Example

```
// Read data burst length of 3 to start address 16.
trans = bfm.create_read_transaction(16, 3);
trans.size = AXI4_BYTES_4;
```

# execute_transaction()

This task executes a master transaction previously created by the *create_write_transaction()*, or *create_read_transaction()*, functions. The transaction can be blocking (default) or non-blocking, defined by the transaction record *operation_mode* field.

The results of *execute_transaction()* for write transactions varies based on how write transaction fields are set. If the *gen_write_strobes* transaction field is set, *execute_transaction()* automatically corrects any previously set *write_strobes*. However, if the *gen_write_strobes* field is not set, then any previously assigned *write_strobes* will be passed through onto the *WSTRB* protocol signals, which can result in a protocol violation if not correctly set. Refer to "Automatic Correction of Byte Lane Strobes" on page 180 for more details.

If a write transaction *write_data_mode* field is set to **_DATA_WITH_ADDRESS*, *execute_transaction()* calls the *execute_write_addr_phase()* and *execute_write_data_burst()* tasks simultaneously, otherwise *execute_write_data_burst()* will be called after *execute_write_addr_phase()* so that the write data burst occurs after the write address phase (default). It will then call the *get_write_response_phase()* task to complete the write transaction.

For a read transaction, *execute_transaction()* calls the *execute_read_addr_phase()* task followed by the *get_read_data_burst()* task to complete the read transaction.

**Prototype**

```
// * = axi | axi4
task automatic execute_transaction
(
   *_transaction trans
);
```

**Arguments** trans — The **_transaction* record.

**Returns** None

## AXI3 Example

```
// Declare a local variable to hold the transaction record.
axi_transaction read_trans;

// Create a read transaction with start address of 0 and assign
// it to the local read_trans variable.
read_trans = bfm.create_read_transaction(0);

....

// Execute the read_trans transaction.
bfm.execute_transaction(read_trans);
```

## AXI4 Example

```
// Declare a local variable to hold the transaction record.
axi4_transaction read_trans;

// Create a read transaction with start address of 0 and assign
// it to the local read_trans variable.
read_trans = bfm.create_read_transaction(0);

....

// Execute the read_trans transaction.
bfm.execute_transaction(read_trans);
```

# execute_write_addr_phase()

This task executes a master write address phase previously created by the *create_write_transaction()* function. This phase can be blocking (default) or nonblocking, defined by the transaction *operation_mode* field.

It sets the *AWVALID* protocol signal at the appropriate time defined by the transaction *address_valid_delay* field.

**Prototype**

```
// * = axi | axi4
task automatic execute_write_addr_phase
(
   *_transaction trans
);
```

**Arguments** trans — The **_transaction* record.

**Returns** None

## AXI3 Example

```
// Declare a local variable to hold the transaction record.
axi_transaction write_trans;

// Create a write transaction with start address of 0 and assign
// it to the local write_trans variable.
write_trans = bfm.create_write_transaction(0);

....

// Execute the write_trans transaction.
bfm.execute_transaction(write_trans);
```

## AXI4 Example

```
// Declare a local variable to hold the transaction record.
axi4_transaction write_trans;

// Create a write transaction with start address of 0 and assign
// it to the local write_trans variable.
write_trans = bfm.create_write_transaction(0);

....

// Execute the write_trans transaction.
bfm.execute_transaction(write_trans);
```

# execute_read_addr_phase()

This task executes a master read address phase previously created by the *create_read_transaction()* function. This phase can be blocking (default) or nonblocking, defined by the transaction *operation_mode* field.

It sets the *ARVALID* protocol signal at the appropriate time, defined by the transaction *address_valid_delay* field.

**Prototype**

```
// * = axi | axi4
task automatic execute_read_addr_phase
(
   *_transaction trans
);
```

**Arguments** trans — The **_transaction* record.

**Returns** None

## AXI3 Example

```
// Declare a local variable to hold the transaction record.
axi_transaction read_trans;

// Create a read transaction with start address of 0 and assign
// it to the local read_trans variable.
read_trans = bfm.create_read_transaction(0);

....

// Execute the read_trans transaction.
bfm.execute_transaction(read_trans);
```

## AXI4 Example

```
// Declare a local variable to hold the transaction record.
axi4_transaction read_trans;

// Create a read transaction with start address of 0 and assign
// it to the local read_trans variable.
read_trans = bfm.create_read_transaction(0);

....

// Execute the read_trans transaction.
bfm.execute_transaction(read_trans);
```

# execute_write_data_burst()

This task executes a write data burst previously created by the *create_write_transaction()* task. This burst can be blocking (default) or nonblocking, defined by the transaction *operation_mode* field.

If the transaction *gen_write_strobes* field is set, this task automatically corrects any previously set *write_strobes* field array elements. If the *gen_write_strobes* field is not set then any previously assigned *write_strobes* field array elements will be passed through onto the *WSTRB* protocol signals, which can result in a protocol violation if the *WSTRB* signals are not correctly set. Refer to "Automatic Correction of Byte Lane Strobes" on page 180 for more details.

It calls the *execute_write_data_phase()* task for each beat of the data burst, with the length of the burst defined by the transaction *burst_length* field.

**Prototype**

```
// * = axi | axi4
task automatic execute_write_data_burst
(
   *_transaction trans
);
```

**Arguments** trans — The **_transaction* record.

**Returns** None

## AXI3 Example

```
// Declare a local variable to hold the transaction record.
axi_transaction write_trans;

// Create a write transaction with start address of 0 and assign
// it to the local write_trans variable.
write_trans = bfm.create_write_transaction(0);

....

// Execute the write_trans transaction.
bfm.execute_write_data_burst(write_trans);
```

## AXI4 Example

```
// Declare a local variable to hold the transaction record.
axi4_transaction write_trans;

// Create a write transaction with start address of 0 and assign
// it to the local write_trans variable.
write_trans = bfm.create_write_transaction(0);

....

// Execute the write_trans transaction.
bfm.execute_write_data_burst(write_trans);
```

# execute_write_data_phase()

This task executes a write data phase (beat) previously created by the *create_write_transaction()* task. This phase can be blocking (default) or nonblocking, defined by the transaction record *operation_mode* field.

The *execute_write_data_phase()* sets the *WVALID* protocol signal at the appropriate time defined by the transaction record *data_valid_delay* field and sets the *data_beat_done* array *index* element field to 1 when the phase completes.

**Prototype**

```
// * = axi | axi4
task automatic execute_write_data_phase
(
     *_transaction trans,
     int index = 0, // Optional
     output bit last
     );
```

**Arguments**

| | |
|---|---|
| trans | The **_transaction* record. |
| index | Data phase (beat) number |
| last | Flag to indicate that this phase is the last in the burst. |

**Returns** None

## AXI3 Example

```
// Declare a local variable to hold the transaction record.
axi_transaction write_trans;

// Create a write transaction with start address of 0 and assign
// it to the local write_trans variable.
write_trans = bfm.create_write_transaction(0);

....

// Execute the write data phase for the first beat of the
// write_trans transaction.
bfm.execute_write_data_phase(write_trans, 0, last);

// Execute the write data phase for the second beat of the
// write_trans transaction.
bfm.execute_write_data_phase(write_trans, 1, last);
```

## AXI4 Example

```
// Declare a local variable to hold the transaction record.
axi4_transaction write_trans;

// Create a write transaction with start address of 0 and assign
// it to the local write_trans variable.
write_trans = bfm.create_write_transaction(0);

....

// Execute the write data phase for the first beat of the
// write_trans transaction.
bfm.execute_write_data_phase(write_trans, 0, last);

// Execute the write data phase for the second beat of the
// write_trans transaction.
bfm.execute_write_data_phase(write_trans, 1, last);
```

# get_read_data_burst()

This blocking task gets a read data burst previously created by the *create_read_transaction()* function.

It calls the *get_read_data_phase()* task for each beat of the data burst, with the length of the burst defined by the transaction record *burst_length* field.

**Prototype**

```
// * = axi | axi4
task automatic get_read_data_burst
(
   *_transaction trans
);
```

**Arguments**

| | |
|---|---|
| trans | The *_*transaction* record. |

**Returns**

None

## AXI3 Example

```
// Declare a local variable to hold the transaction record.
axi_transaction read_trans;

// Create a read transaction with start address of 0 and assign
// it to the local read_trans variable.
read_trans = bfm.create_read_transaction(0);

....

// Get the read data burst for the read_trans transaction.
bfm.get_read_data_burst(read_trans);
```

## AXI4 Example

```
// Declare a local variable to hold the transaction record.
axi4_transaction read_trans;

// Create a read transaction with start address of 0 and assign
// it to the local read_trans variable.
read_trans = bfm.create_read_transaction(0);

....

// Execute the read_trans transaction.
bfm.execute_transaction(read_trans);
```

# get_read_data_phase()

This blocking task gets a read data phase previously created by the *create_read_transaction()* task.

The *get_read_data_phase()* sets the *data_beat_done* array *index* element field to 1 when the phase completes. If this is the last phase (beat) of the burst, then it sets the *transaction_done* field to 1 to indicate the whole read transaction is complete.

**Note**

For AXI3, the *get_read_data_phase()* also sets the *RREADY* protocol signal at the appropriate time, defined by the transaction record *data_ready_delay* field.

**Prototype**

```
// * = axi | axi4
task automatic get_read_data_phase
(
   *_transaction trans,
   int index = 0 // Optional
);
```

**Arguments**

| | |
|---|---|
| trans | The **_transaction* record. |
| index | (Optional) Data phase (beat) number. |

**Returns** None

## AXI3 Example

```
// Declare a local variable to hold the transaction record.
axi_transaction read_trans;

// Create a read transaction with start address of 0 and assign
// it to the local read_trans variable.
read_trans = bfm.create_read_transaction(0);

....

// Get the read data phase for the first beat of the
// read_trans transaction.
bfm.get_read_data_phase(read_trans, 0);

// Get the read data phase for the second beat of the
// read_trans transaction.
bfm.get_read_data_phase(read_trans, 1);
```

## AXI4 Example

```
// Declare a local variable to hold the transaction record.
axi4_transaction read_trans;

// Create a read transaction with start address of 0 and assign
// it to the local read_trans variable.
read_trans = bfm.create_read_transaction(0);

....

// Get the read data phase for the first beat of the
// read_trans transaction.
bfm.get_read_data_phase(read_trans, 0);

// Get the read data phase for the second beat of the
// read_trans transaction.
bfm.get_read_data_phase(read_trans, 1);
```

# get_write_response_phase()

This blocking task gets a write response phase previously created by the *create_write_transaction()* task.

The *get_write_response_phase()* sets the *transaction_done* field to 1 when the transaction completes to indicate the whole transaction is complete.

**Note**

For AXI3, the *get_write_response_phase()* also sets the *BREADY* protocol signal at the appropriate time, defined by the transaction record *write_response_ready_delay* field.

**Prototype**

```
// * = axi | axi4
task automatic get_write_response_phase
 (
     *_transaction trans
 );
```

**Arguments** trans — The **_transaction* record.

**Returns** None

## AXI3 Example

```
// Declare a local variable to hold the transaction record.
axi_transaction write_trans;

// Create a write transaction with start address of 0 and assign
// it to the local write_trans variable.
write_trans = bfm.create_write_transaction(0);

....

// Get the write response phase of the write_trans transaction.
bfm.get_write_response_phase(write_trans);
```

## AXI4 Example

```
// Declare a local variable to hold the transaction record.
axi4_transaction write_trans;

// Create a write transaction with start address of 0 and assign
// it to the local write_trans variable.
write_trans = bfm.create_write_transaction(0);

....

// Get the write response phase of the write_trans transaction.
bfm.get_write_response_phase(write_trans);
```

# get_read_addr_ready()

This blocking AXI4 task returns the value of the read address channel *ARREADY* signal using the *ready* argument. It will block for one *ACLK* period.

**Prototype**

```
task automatic get_read_addr_ready
(
   output bit ready
);
```

**Arguments** ready — The value of the *ARREADY* signal.

**Returns** ready

## AXI3 BFM

**Note**

The *get_read_addr_ready()* task is not available in the AXI3 BFM.

## AXI4 Example

```
// Get the ARREADY signal value
bfm.get_read_addr_ready(ready);
```

# get_read_data_cycle()

This blocking AXI4 task waits until the read data channel *RVALID* signal is asserted.

**Prototype** `task automatic get_read_data_cycle();`
**Arguments** None
**Returns** None

## AXI3 BFM

**Note**
The *get_read_data_cycle()* task is not available in the AXI3 BFM.

## AXI4 Example

```
// Waits until the read data channel RVALID signal is asserted.
bfm.get_read_data_cycle();
```

# get_write_addr_ready()

This blocking AXI4 task returns the value of the write address channel *AWREADY* signal using the *ready* argument. It will block for one *ACLK* period.

**Prototype**

```
task automatic get_write_addr_ready
(
   output bit ready
);
```

**Arguments**

| | |
|---|---|
| ready | The value of the A*WREADY* signal. |

**Returns** None

## AXI3 BFM

**Note**

The *get_write_addr_ready()* task is not available in the AXI3 BFM.

## AXI4 Example

```
// Get the value of the AWREADY signal
bfm.get_write_addr_ready();
```

# get_write_data_ready()

This blocking AXI4 task returns the value of the write data channel *WREADY* signal using the *ready* argument. It will block for one *ACLK* period.

**Prototype**

```
task automatic get_write_data_ready
(
   output bit ready
);
```

**Arguments** ready — The value of the *WREADY* signal.

**Returns** None

## AXI3 BFM

**Note**

The *get_write_data_ready()* task is not available in the AXI3 BFM.

## AXI4 Example

```
// Get the value of the WREADY signal
bfm.get_write_data_ready();
```

# get_write_response_cycle()

This blocking AXI4 task waits until the write response channel *BVALID* signal is asserted.

**Prototype** `task automatic get_write_response_cycle();`
**Arguments** None
**Returns** None

## AXI3 BFM

**Note**
The *get_write_response_cycle()* task is not available in the AXI3 BFM.

## AXI4 Example

```
// Wait until the write response channel BVALID signal is asserted.
bfm.get_write_response_cycle();
```

# execute_read_data_ready()

This AXI4 task executes a read data ready by placing the *ready* argument value onto the *RREADY* signal. It will block for one *ACLK* period.

**Prototype**

```
task automatic execute_read_data_ready
(
    bit ready
);
```

**Arguments** ready — The value to be placed onto the *RREADY* signal

**Returns** None

## AXI3 BFM

**Note**

The *execute_read_data_ready()* task is not available in the AXI3 BFM. Use the *get_read_data_phase()* task along with the transaction record *data_ready_delay* field.

## AXI4 Example

```
// Assert and deassert the RREADY signal
forever begin
   bfm.execute_read_data_ready(1'b0);

   bfm.wait_on(AXI4_CLOCK_POSEDGE);
   bfm.wait_on(AXI4_CLOCK_POSEDGE);

   bfm.execute_read_data_ready(1'b1);

   bfm.wait_on(AXI4_CLOCK_POSEDGE);
end
```

# execute_write_resp_ready()

This AXI4 task executes a write response ready by placing the *ready* argument value onto the *BREADY* signal. It will block for one *ACLK* period.

**Prototype**

```
task automatic execute_write_resp_ready
(
    bit ready
);
```

**Arguments** ready — The value to be placed onto the *BREADY* signal

**Returns** None

## AXI3 BFM

**Note**

The *execute_write_resp_ready()* task is not available in the AXI3 BFM. Use the *get_write_response_phase()* task along with the transaction record *write_response_ready_delay* field.

## AXI4 Example

```
// Assert and deassert the BREADY signal
forever begin
   bfm.execute_write_resp_ready(1'b0);

   bfm.wait_on(AXI4_CLOCK_POSEDGE);
   bfm.wait_on(AXI4_CLOCK_POSEDGE);

   bfm.execute_write_resp_ready(1'b1);

   bfm.wait_on(AXI4_CLOCK_POSEDGE);
end
```

# wait_on()

This blocking task waits for an event(s) on the *ACLK* or *ARESETn* signals to occur before proceeding. An optional *count* argument waits for the number of events equal to *count*.

**Prototype**

```
// * = axi | axi4
// ** = AXI| AXI4
task automatic wait_on
(
   *_wait_e phase,
   input int count = 1 //Optional
);
```

**Arguments**

| | |
|---|---|
| phase | Wait for:<br>**_CLOCK_POSEDGE<br>**_CLOCK_NEGEDGE<br>**_CLOCK_ANYEDGE<br>**_CLOCK_0_TO_1<br>**_CLOCK_1_TO_0<br>**_RESET_POSEDGE<br>**_RESET_NEGEDGE<br>**_RESET_ANYEDGE<br>**_RESET_0_TO_1<br>**_RESET_1_TO_0 |
| count | (Optional) Wait for a number of events to occur set by *count*. (default = 1) |

**Returns** None

## AXI3 Example

```
bfm.wait_on(AXI_RESET_POSEDGE);
bfm.wait_on(AXI_CLOCK_POSEDGE,10);
```

## AXI4 Example

```
bfm.wait_on(AXI4_RESET_POSEDGE);
bfm.wait_on(AXI4_CLOCK_POSEDGE,10);
```

# Chapter 4
# SystemVerilog AXI3 and AXI4 Slave BFMs

This section provides information about the SystemVerilog AXI3 and AXI4 slave BFMs. Each BFM has an API that contains tasks and functions to configure the BFM and to access the dynamic Transaction Record during the lifetime of the transaction.

**Note**

Due to AXI3 protocol specification changes, for some BFM tasks, you reference the AXI3 BFM by specifying AXI instead of AXI3.

## Slave BFM Protocol Support

This section defines protocol support for various AXI BFMs.

The AXI3 slave BFM supports the AMBA AXI3 protocol with restrictions described in "Protocol Restrictions" on page 1. In addition to the standard protocol, it supports user sideband signals *AWUSER* and *ARUSER*. The AXI4 slave BFM supports the AMBA AXI4 protocol with restrictions described in "Protocol Restrictions" on page 1.

## Slave Timing and Events

For detailed timing diagrams of the protocol bus activity refer to the relevant AMBA AXI Protocol Specification chapter, which you can use to reference details of the following slave BFM API timing and events.

The specification does not define any timescale or clock period with signal events sampled and driven at rising *ACLK* edges. Therefore, the slave BFM does not contain any timescale, timeunit, or timeprecision declarations with the signal setup and hold times specified in units of simulator time-steps.

The simulator time-step resolves to the smallest of all the time-precision declarations in the testbench and design IP based on using the directives, declarations, options, and initialization files below:

- `timescale directives in design elements.
- timeprecision declarations in design elements.
- compiler command-line options.
- simulation command-line options
- local or site-wide simulator initialization files.

If there is no timescale directive, the default time unit and time precision are tool specific. Using timeunit and timeprecision declarations are recommended. Refer to the SystemVerilog LRM section 3.14 for details.

# Slave BFM Configuration

The slave BFM supports the full range of signals defined for the AMBA AXI protocol specification. It has parameters that can be used to configure the widths of the address, data and ID signals, and transaction fields to configure timeout factors, slave exclusive support, and setup and hold times, etc.

The address and data and ID signal widths can be changed from their default settings by assigning them with new values, usually performed in the top-level module of the testbench. These new values are then passed into the slave BFM using a parameter port list of the slave BFM module. For example, the code extract below shows the AXI3 slave BFM with the address, data and ID signal widths defined in *module top()* and passed in to the slave BFM *mgc_axi_slave* parameter port list:

module top ();

```
    parameter AXI_ADDRESS_WIDTH = 24;
    parameter AXI_RDATA_WIDTH = 16;
    parameter AXI_WDATA_WIDTH = 16;
    parameter AXI_ID_WIDTH = 4;

    mgc_axi_slave #(AXI_ADDRESS_WIDTH, AXI_RDATA_WIDTH, AXI_WDATA_WIDTH,
AXI_ID_WIDTH) bfm_slave(....);
```

**Note**

In the above code extract, the *mgc_axi_slave* is an AXI3 slave BFM interface.

Table 4-1 lists the parameter names for the address, data and ID signals and their default values.

**Table 4-1. Slave BFM Signal Width Parameters**

| Signal Width Parameter | Description |
|---|---|
| **_ADDRESS_WIDTH | Address signal width in bits. This applies to the *ARADDR* and *AWADDR* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 64 |
| **_RDATA_WIDTH | Read data signal width in bits. This applies to the *RDATA* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 1024. |
| **_WDATA_WIDTH | Write data signal width in bits. This applies to the *WDATA* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 1024. |
| **_ID_WIDTH | ID signal width in bits. This applies to the *RID* and *WID* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 18. |
| AXI4_USER_WIDTH | (AXI4) User data signal width in bits. This applies to the *ARUSER*, *AWUSER*, *RUSER*, *WUSER* and *BUSER* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 8. |
| AXI4_REGION_MAP_SIZE | (AXI4) Region signal width in bits. This applies to the *ARREGION* and *AWREGION* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 16. |

A slave BFM has configuration fields that you can set with the *set_config()* function to configure timeout factors, slave exclusive support, setup and hold times, etc. You can also get the value of a configuration field via the *get_config()* function. The full list of configuration fields is described in Table 4-2 below.

**Table 4-2. Slave BFM Configuration**

| Configuration Field | Description |
|---|---|
| **Timing Variables** | |
| **_CONFIG_SETUP_TIME | The setup-time prior to the active edge of *ACLK*, in units of simulator time-steps for all signals.[1] Default: 0. |
| **_CONFIG_HOLD_TIME | The hold-time after the active edge of *ACLK*, in units of simulator time-steps for all signals.[1] Default: 0. |
| AXI_CONFIG_MAX_TRANSACTION_TIME_FACTOR | (AXI3) The maximum timeout duration for a read/write transaction in clock cycles. Default: 100000. |
| AXI_CONFIG_TIMEOUT_MAX_DATA_TRANSFER | (AXI3) The maximum number of write data beats that the AXI3 BFM can generate as part of write data burst of write transfer. Default: 1024. |

**Table 4-2. Slave BFM Configuration**

| Configuration Field | Description |
|---|---|
| **Timing Variables** | |
| **_CONFIG_BURST_TIMEOUT_FACTOR | The maximum delay between the individual phases of a read/write transaction in clock cycles. Default: 10000. |
| AXI4_CONFIG_MAX_LATENCY_AWVALID_ ASSERTION_TO_AWREADY | ((AXI4) The maximum timeout duration from the assertion of *AWVALID* to the assertion of *AWREADY* in clock periods (default 10000). |
| AXI4_CONFIG_MAX_LATENCY_ARVALID_ ASSERTION_TO_ARREADY | (AXI4) The maximum timeout duration from the assertion of *ARVALID* to the assertion of *ARREADY* in clock periods (default 10000). |
| AXI4_CONFIG_MAX_LATENCY_RVALID_ ASSERTION_TO_RREADY | ((AXI4) The maximum timeout duration from the assertion of *RVALID* to the assertion of *RREADY* in clock periods (default 10000). |
| AXI4_CONFIG_MAX_LATENCY_BVALID_ ASSERTION_TO_BREADY | ((AXI4) The maximum timeout duration from the assertion of *BVALID* to the assertion of *BREADY* in clock periods (default 10000). |
| AXI4_CONFIG_MAX_LATENCY_WVALID_ ASSERTION_TO_WREADY | (AXI4) The maximum timeout duration from the assertion of *WVALID* to the assertion of *WREADY* in clock periods (default 10000). |
| **Master Attributes** | |
| AXI_CONFIG_WRITE_CTRL_TO_DATA_MINTIME | (AXI3) The minimum delay from the start of a write control (address) phase to the start of a write data phase in clock cycles. Default: 1. |
| AXI_CONFIG_MASTER_WRITE_DELAY | (AXI3) The master BFM applies the AXI_CONFIG_WRITE_CTRL_TO_ DATA_MINTIME value set.<br>0 = true (default)<br>1 = false |
| AXI_CONFIG_MASTER_DEFAULT_UNDER_RESET | (AXI3) The master BFM drives the *ARVALID*, *AWVALID* and *WVALID* signals low during reset:<br>0 = false (default)<br>1 = true |
| AXI4_CONFIG_ENABLE_QOS | (AXI4) The master participates in the Quality-of-Service scheme. If a master does not participate, the *AWQOS/ARQOS* value used in write/read transactions must be b0000. |

**Table 4-2. Slave BFM Configuration**

| Configuration Field | Description |
|---|---|
| **Slave Attributes** | |
| **_CONFIG_SUPPORT_EXCLUSIVE_ACCESS | Configures the support for an exclusive slave. If enabled the BFM will expect an *EXOKAY* response to a successful exclusive transaction. If disabled the BFM will expect an *OKAY* response to an exclusive transaction. Refer to the AMBA AXI protocol specification for more details.<br>0 = disabled<br>1 = enabled (default) |
| AXI_CONFIG_SLAVE_DEFAULT_UNDER_RESET | (AXI3) The slave BFM drives the *BVALID* and *RVALID* signals low during reset. Refer to the AMBA AXI Protocol specification for more details.<br>0 = false (default)<br>1 = true |
| AXI4_CONFIG_SLAVE_START_ADDR | (AXI4) Configures the start address map for the slave. |
| AXI4_CONFIG_SLAVE_END_ADDR | (AXI4) Configures the end address map for the slave. |
| AXI4_CONFIG_READ_DATA_REORDERING_DEPTH | (AXI4) The slave read reordering depth. Refer to the AMBA AXI Protocol specification for more details. Default: 1. |
| **Error Detection** | |
| **_CONFIG_ENABLE_ALL_ASSERTIONS | Global enable/disable of all assertion checks in the BFM.<br>0 = disabled<br>1 = enabled (default) |

[1.] Refer to Slave Timing and Events for details of simulator time-steps.

# Slave Assertions

Each slave BFM performs protocol error checking using the built-in assertions.

**Note**

The built-in BFM assertions are independent of programming language and simulator.

# AXI3 Assertion Configuration

By default, all built-in assertions are enabled in the slave BFM. To globally disable them in the slave BFM, use the *set_config()* command as the following example illustrates:

```
set_config(AXI_CONFIG_ENABLE_ALL_ASSERTIONS,0)
```

Alternatively, individual built-in assertions can be disabled by using a sequence of *get_config()* and *set_config()* commands on the respective assertion. For example, to disable assertion checking for the *AWLOCK* signal changing between the *AWVALID* and *AWREADY* handshake signals, use the following sequence of commands:

```
// Define a local bit vector to hold the value of the assertion bit vector
bit [255:0] config_assert_bitvector;

// Get the current value of the assertion bit vector
config_assert_bitvector = bfm.get_config(AXI_CONFIG_ENABLE_ASSERTION);

// Assign the AXI_LOCK_CHANGED_BEFORE_AWREADY assertion bit to 0
config_assert_bitvector[AXI_LOCK_CHANGED_BEFORE_AWREADY] = 0;

// Set the new value of the assertion bit vector
bfm.set_config(AXI_CONFIG_ENABLE_ASSERTION, config_assert_bitvector);
```

**Note**

Do not confuse the *AXI_CONFIG_ENABLE_ASSERTION* bit vector with the *AXI_CONFIG_ENABLE_ALL_ASSERTIONS* global enable/disable.

To re-enable the *AXI_LOCK_CHANGED_BEFORE_AWREADY* assertion, follow the above code sequence and assign the assertion in the *AXI_CONFIG_ENABLE_ASSERTION* bit vector to 1.

For a complete listing of AXI3 assertions, refer to "AXI3 Assertions" on page 641.

## AXI4 Assertion Configuration

By default, all built-in assertions are enabled in the slave AXI4 BFM. To globally disable them in the slave BFM, use the *set_config()* command as the following example illustrates:

```
set_config(AXI4_CONFIG_ENABLE_ALL_ASSERTIONS,0);
```

Alternatively, individual built-in assertions can be disabled by using a sequence of *get_config()* and *set_config()* commands on the respective assertion. For example, to disable assertion checking for the *AWLOCK* signal changing between the *AWVALID* and *AWREADY* handshake signals, use the following sequence of commands:

```
// Define a local bit vector to hold the value of the assertion bit vector
bit [255:0] config_assert_bitvector;

// Get the current value of the assertion bit vector
config_assert_bitvector = bfm.get_config(AXI4_CONFIG_ENABLE_ASSERTION);

// Assign the AXI4_LOCK_CHANGED_BEFORE_AWREADY assertion bit to 0
config_assert_bitvector[AXI4_LOCK_CHANGED_BEFORE_AWREADY] = 0;

// Set the new value of the assertion bit vector
bfm.set_config(AXI4_CONFIG_ENABLE_ASSERTION, config_assert_bitvector);
```

**Note**

Do not confuse the *AXI4_CONFIG_ENABLE_ASSERTION* bit vector with the *AXI4_CONFIG_ENABLE_ALL_ASSERTIONS* global enable/disable.

To re-enable the *AXI4_LOCK_CHANGED_BEFORE_AWREADY* assertion, follow the above code sequence and assign the assertion in the *AXI4_CONFIG_ENABLE_ASSERTION* bit vector to 1.

For a complete listing of AXI4 assertions, refer to "AXI4 Assertions" on page 654.

# SystemVerilog Slave API

This section describes the SystemVerilog Slave API.

# set_config()

This function sets the configuration of the slave BFM.

**Prototype**

```
// * = axi | axi4
function void set_config
(
   input *_config_e config_name,
   input *_max_bits_t config_val
);
```

**Arguments**

config_name

(AXI3) Configuration name:
- AXI_CONFIG_SETUP_TIME
- AXI_CONFIG_HOLD_TIME
- AXI_CONFIG_MAX_TRANSACTION_TIME_FACTOR
- AXI_CONFIG_TIMEOUT_MAX_DATA_TRANSFER
- AXI_CONFIG_BURST_TIMEOUT_FACTOR
- AXI_CONFIG_WRITE_CTRL_TO_DATA_MINTIME
- AXI_CONFIG_MASTER_WRITE_DELAY
- AXI_CONFIG_MASTER_DEFAULT_UNDER_RESET
- AXI_CONFIG_SLAVE_DEFAULT_UNDER_RESET
- AXI_CONFIG_ENABLE_ALL_ASSERTIONS
- AXI_CONFIG_MASTER_ERROR_POSITION
- AXI_CONFIG_SUPPORT_EXCLUSIVE_ACCESS

(AXI4) Configuration name:
- AXI4_CONFIG_SETUP_TIME
- AXI4_CONFIG_HOLD_TIME
- AXI4_CONFIG_BURST_TIMEOUT_FACTOR
- AXI4_CONFIG_ENABLE_RLAST
- AXI4_CONFIG_ENABLE_SLAVE_EXCLUSIVE
- AXI4_CONFIG_ENABLE_ALL_ASSERTIONS
- AXI4_CONFIG_ENABLE_ASSERTION
- AXI4_CONFIG_MAX_LATENCY_AWVALID_ASSERTION_TO_AWREADY
- AXI4_CONFIG_MAX_LATENCY_ARVALID_ASSERTION_TO_ARREADY
- AXI4_CONFIG_MAX_LATENCY_RVALID_ASSERTION_TO_RREADY
- AXI4_CONFIG_MAX_LATENCY_BVALID_ASSERTION_TO_BREADY
- AXI4_CONFIG_MAX_LATENCY_WVALID_ASSERTION_TO_WREADY
- AXI4_CONFIG_ENABLE_QOS
- AXI4_CONFIG_READ_DATA_REORDERING_DEPTH
- AXI4_CONFIG_SLAVE_START_ADDR
- AXI4_CONFIG_SLAVE_END_ADDR

config_val

See "Slave BFM Configuration" on page 66 for descriptions and valid values.

**Returns**

None

## AXI3 Example

```
set_config(AXI_CONFIG_SUPPORT_EXCLUSIVE_ACCESS, 1);
set_config(AXI_CONFIG_BURST_TIMEOUT_FACTOR, 1000);
```

## AXI4 Example

```
set_config(AXI4_CONFIG_ENABLE_SLAVE_EXCLUSIVE, 1);
set_config(AXI4_CONFIG_BURST_TIMEOUT_FACTOR, 1000);
```

# get_config()

This function gets the configuration of the slave BFM.

**Prototype**

```
// * = axi | axi4
function void get_config
(
   input *_config_e config_name,
);
```

**Arguments**

| | | |
|---|---|---|
| config_name | (AXI3) Configuration name:<br>AXI_CONFIG_SETUP_TIME<br>AXI_CONFIG_HOLD_TIME<br>AXI_CONFIG_MAX_TRANSACTION_TIME_FACTOR<br>AXI_CONFIG_TIMEOUT_MAX_DATA_TRANSFER<br>AXI_CONFIG_BURST_TIMEOUT_FACTOR<br>AXI_CONFIG_WRITE_CTRL_TO_DATA_MINTIME<br>AXI_CONFIG_MASTER_WRITE_DELAY<br>AXI_CONFIG_MASTER_DEFAULT_UNDER_RESET<br>AXI_CONFIG_SLAVE_DEFAULT_UNDER_RESET<br>AXI_CONFIG_ENABLE_ALL_ASSERTIONS<br>AXI_CONFIG_MASTER_ERROR_POSITION<br>AXI_CONFIG_SUPPORT_EXCLUSIVE_ACCESS<br><br>(AXI4) Configuration name:<br>AXI4_CONFIG_SETUP_TIME<br>AXI4_CONFIG_HOLD_TIME<br>AXI4_CONFIG_BURST_TIMEOUT_FACTOR<br>AXI4_CONFIG_ENABLE_RLAST<br>AXI4_CONFIG_ENABLE_SLAVE_EXCLUSIVE<br>AXI4_CONFIG_ENABLE_ALL_ASSERTIONS<br>AXI4_CONFIG_ENABLE_ASSERTION<br>AXI4_CONFIG_MAX_LATENCY_AWVALID_ASSERTION_TO_AWREADY<br>AXI4_CONFIG_MAX_LATENCY_ARVALID_ASSERTION_TO_ARREADY<br>AXI4_CONFIG_MAX_LATENCY_RVALID_ASSERTION_TO_RREADY<br>AXI4_CONFIG_MAX_LATENCY_BVALID_ASSERTION_TO_BREADY<br>AXI4_CONFIG_MAX_LATENCY_WVALID_ASSERTION_TO_WREADY<br>AXI4_CONFIG_ENABLE_QOS<br>AXI4_CONFIG_READ_DATA_REORDERING_DEPTH<br>AXI4_CONFIG_SLAVE_START_ADDR<br>AXI4_CONFIG_SLAVE_END_ADDR |

**Returns**

| | |
|---|---|
| config_val | See "Slave BFM Configuration" on page 66 for descriptions and valid values. |

## AXI3 Example

```
get_config(AXI_CONFIG_SUPPORT_EXCLUSIVE_ACCESS);
get_config(AXI_CONFIG_BURST_TIMEOUT_FACTOR);
```

## AXI4 Example

```
get_config(AXI4_CONFIG_ENABLE_SLAVE_EXCLUSIVE);
get_config(AXI4_CONFIG_BURST_TIMEOUT_FACTOR);
```

# create_slave_transaction()

This nonblocking function creates a slave transaction. All transaction fields default to legal protocol values, unless previously assigned a value. It returns with the **_transaction* record.

**Prototype**

```
// * = axi | axi4
// ** = AXI| AXI4
function automatic *_transaction create_write_transaction();
```

**Protocol Transaction Fields**

| | |
|---|---|
| addr | Start address |
| burst_length | Burst length. Default: 0. |
| size | Burst size. Default: width of bus:<br>**_BYTES_1;<br>**_BYTES_2;<br>**_BYTES_4;<br>**_BYTES_8;<br>**_BYTES_16;<br>**_BYTES_32;<br>**_BYTES_64;<br>**_BYTES_128; |
| burst | Burst type:<br>**_FIXED;<br>**_INCR; (default)<br>**_WRAP;<br>**_BURST_RSVD; |
| lock | Burst lock:<br>**_NORMAL; (default)<br>**_EXCLUSIVE;<br>(AXI3) AXI_LOCKED;<br>(AXI3) AXI_LOCK_RSVD; |
| cache | (AXI3) Burst cache:<br>AXI_NONCACHE_NONBUF; (default)<br>AXI_BUF_ONLY;<br>AXI_CACHE_NOALLOC;<br>AXI_CACHE_BUF_NOALLOC;<br>AXI_CACHE_RSVD0;<br>AXI_CACHE_RSVD1;<br>AXI_CACHE_WTHROUGH_ALLOC_R_ONLY;<br>AXI_CACHE_WBACK_ALLOC_R_ONLY;<br>AXI_CACHE_RSVD2;<br>AXI_CACHE_RSVD3;<br>AXI_CACHE_WTHROUGH_ALLOC_W_ONLY;<br>AXI_CACHE_WBACK_ALLOC_W_ONLY;<br>AXI_CACHE_RSVD4;<br>AXI_CACHE_RSVD5;<br>AXI_CACHE_WTHROUGH_ALLOC_RW;<br>AXI_CACHE_WBACK_ALLOC_RW; |

| | | |
|---|---|---|
| **Protocol Transaction Fields** | cache | (AXI4) Burst cache:<br>AXI4_NONMODIFIABLE_NONBUF; (default)<br>AXI4_BUF_ONLY;<br>AXI4_CACHE_NOALLOC;<br>AXI4_CACHE_2;<br>AXI4_CACHE_3;<br>AXI4_CACHE_RSVD4;<br>AXI4_CACHE_RSVD5;<br>AXI4_CACHE_6;<br>AXI4_CACHE_7;<br>AXI4_CACHE_RSVD8;<br>AXI4_CACHE_RSVD9;<br>AXI4_CACHE_10;<br>AXI4_CACHE_11;<br>AXI4_CACHE_RSVD12;<br>AXI4_CACHE_RSVD12;<br>AXI4_CACHE_14;<br>AXI4_CACHE_15; |
| | prot | Protection:<br>**_NORM_SEC_DATA; (default)<br>**_PRIV_SEC_DATA;<br>**_NORM_NONSEC_DATA;<br>**_PRIV_NONSEC_DATA;<br>**_NORM_SEC_INST;<br>**_PRIV_SEC_INST;<br>**_NORM_NONSEC_INST;<br>**_PRIV_NONSEC_INST; |
| | id | Burst ID. |
| | data_words | Data words array. |
| | write_strobes | Write strobes array:<br>Each strobe 0 or 1. |
| | resp | Burst response:<br>**_OKAY;<br>**_EXOKAY;<br>**_SLVERR;<br>**_DECERR; |
| | region | (AXI4) Region identifier. |
| | qos | (AXI4) Quality-of-Service identifier. |
| | addr_user | Address channel user data. |
| | data_user | (AXI4) Data channel user data. |
| | resp_user | (AXI4) Response channel user data. |
| | read_or_write | Read or write transaction flag:<br>**_TRANS_READ;<br>**_TRANS_WRITE |
| **Operational Transaction Fields** | gen_write_strobes | Correction of write strobes for invalid byte lanes:<br>0 = write_strobes passed through to protocol signals.<br>1 = write_strobes auto-corrected for invalid byte lanes (default). |
| | operation_mode | Operation mode:<br>**_TRANSACTION_NON_BLOCKING;<br>**_TRANSACTION_BLOCKING; (default) |
| | delay_mode | (AXI3) Delay mode:<br>AXI_VALID2READY; (default)<br>AXI_TRANS2READY; |

| | | |
|---|---|---|
| **Operational Transaction Fields** | write_data_mode | Write data mode:<br>**_DATA_AFTER_ADDRESS; (default)<br>**_DATA_WITH_ADDRESS; |
| | address_valid_delay | Address channel *ARVALID/AWVALID* delay measured in *ACLK* cycles for this transaction (default = 0). |
| | data_valid_delay | Write data channel *WVALID* delay array measured in *ACLK* cycles for this transaction (default = 0 for all elements). |
| | write_response_ready_delay | Write response channel *BREADY* delay measured in *ACLK* cycles for this transaction (default = 0). |
| | data_beat_done | Write data channel beat *done* flag array for this transaction. |
| | transaction_done | Write transaction *done* flag for this transaction. |
| **Returns** | The **_transaction* record. | |

## Example

```
// Create a slave transaction.
trans = bfm.create_slave_transaction();
```

# execute_read_data_burst()

This task executes a slave read data burst previously created by the *create_slave_transaction()* function. The transaction can be blocking (default), or non-blocking, defined by the transaction record *operation_mode* field.

It calls the *execute_read_data_phase()* task for each beat of the data burst, with the length of the burst defined by the transaction *burst_length* field.

**Prototype**

```
// * = axi | axi4
task automatic execute_read_data_burst
(
   *_transaction trans
);
```

**Arguments** trans — The **_transaction* record.

**Returns** None

## AXI3 Example

```
// Declare a local variable to hold the transaction record.
axi_transaction read_trans;

// Create a slave transaction and assign it to the local
// read_trans variable.
read_trans = bfm.create_slave_transaction();

....

// Execute the read_trans read data burst.
bfm.execute_read_data_burst(read_trans);
```

## AXI4 Example

```
// Declare a local variable to hold the transaction record.
axi4_transaction read_trans;

// Create a slave transaction and assign it to the local
// read_trans variable.
read_trans = bfm.create_slave_transaction();

....

// Execute the read_trans read data burst.
bfm.execute_read_data_burst(read_trans);
```

# execute_read_data_phase()

This task executes a read data phase (beat) previously created by the *create_slave_transaction()* task. This phase can be blocking (default), or non-blocking, defined by the transaction record *operation_mode* field.

The *execute_read_data_phase()* sets the *RVALID* protocol signal at the appropriate time defined by the transaction record *data_valid_delay* field and sets the *data_beat_done* array *index* element field to 1 on completion of the phase. If this is the last phase (beat) of the burst then this task sets the *transaction_done* field to 1 to indicate the whole read transaction has completed.

**Prototype**

```
// * = axi | axi4
task automatic execute_read_data_phase
(
   *_transaction trans,
   int index = 0 // Optional
);
```

**Arguments**

| | |
|---|---|
| trans | The **_transaction* record. |
| index | Data phase (beat) number |

**Returns** None

## AXI3 Example

```
// Declare a local variable to hold the transaction record.
axi_transaction read_trans;

// Create a slave transaction and assign it to the local
// read_trans variable.
read_trans = bfm.create_slave_transaction();

....

// Execute the read data phase for the first beat of the
// read_trans transaction.
bfm.execute_read_data_phase(read_trans, 0);

// Execute the read data phase for the second beat of the
// read_trans transaction.
bfm.execute_read_data_phase(read_trans, 1);
```

## AXI4 Example

```
// Declare a local variable to hold the transaction record.
axi4_transaction read_trans;

// Create a slave transaction and assign it to the local
// read_trans variable.
read_trans = bfm.create_slave_transaction();

....

// Execute the read data phase for the first beat of the
// read_trans transaction.
bfm.execute_read_data_phase(read_trans, 0);

// Execute the read data phase for the second beat of the
// read_trans transaction.
bfm.execute_read_data_phase(read_trans, 1);
```

# execute_write_response_phase()

This task executes a write phase previously created by the *create_slave_transaction()* task. This phase can be blocking (default) or non-blocking, defined by the transaction record *operation_mode* field.

It sets the *BVALID* protocol signal at the approriate time defined by the transaction record *write_response_valid_delay* field and sets the *transaction_done* field to 1 on completion of the phase to indicate the whole transaction has completed.

**Prototype**

```
// * = axi | axi4
task automatic execute_write_response_phase
(
   *_transaction trans
);
```

**Arguments**

| | |
|---|---|
| trans | The **_transaction* record. |

**Returns** None

## AXI3 Example

```
// Declare a local variable to hold the transaction record.
axi_transaction write_trans;

// Create a slave transaction and assign it to the local
// write_trans variable.
write_trans = bfm.create_slave_transaction();

....

// Execute the write response phase for the write_trans transaction.
bfm.execute_write_response_phase(write_trans);
```

## AXI4 Example

```
// Declare a local variable to hold the transaction record.
axi4_transaction write_trans;

// Create a slave transaction and assign it to the local
// write_trans variable.
write_trans = bfm.create_slave_transaction();

....

// Execute the write response phase for the write_trans transaction.
bfm.execute_write_response_phase(write_trans);
```

# get_write_addr_phase()

This blocking task gets a write address phase previously created by the *create_slave_transaction()* function.

**Note**

For AXI3, the *get_write_addr_phase()* also sets the *AWREADY* protocol signal at the appropriate time, defined by the transaction record *address_ready_delay* field.

**Prototype**

```
// * = axi | axi4
task automatic get_write_addr_phase
(
   *_transaction trans
);
```

**Arguments** trans — The **_transaction* record.

**Returns** None

## AXI3 Example

```
// Declare a local variable to hold the transaction record.
axi_transaction write_trans;

// Create a slave transaction and assign it to the local
// write_trans variable.
write_trans = bfm.create_slave_transaction();

....

// Get the write address phase of the write_trans transaction.
bfm.get_write_addr_phase(write_trans);
```

## AXI4 Example

```
// Declare a local variable to hold the transaction record.
axi4_transaction write_trans;

// Create a slave transaction and assign it to the local
// write_trans variable.
write_trans = bfm.create_slave_transaction();

....

// Get the write address phase of the write_trans transaction.
bfm.get_write_addr_phase(write_trans);
```

# get_read_addr_phase()

This blocking task gets a read address phase previously created by the *create_slave_transaction()* function.

**Note**

For AXI3, the *get_read_addr_phase()* also sets the *ARREADY* protocol signal at the appropriate time, defined by the transaction record *address_ready_delay* field.

**Prototype**

```
// * = axi | axi4
task automatic get_read_addr_phase
(
   *_transaction trans
);
```

**Arguments** trans — The **_transaction* record.

**Returns** None

## AXI3 Example

```
// Declare a local variable to hold the transaction record.
axi_transaction read_trans;

// Create a slave transaction and assign it to the local
// read_trans variable.
read_trans = bfm.create_slave_transaction();

....

// Get the read address phase of the read_trans transaction.
bfm.get_read_addr_phase(read_trans);
```

## AXI4 Example

```
// Declare a local variable to hold the transaction record.
axi4_transaction read_trans;

// Create a slave transaction and assign it to the local
// read_trans variable.
read_trans = bfm.create_slave_transaction();

....

// Get the read address phase of the read_trans transaction.
bfm.get_read_addr_phase(read_trans);
```

# get_write_data_phase()

This blocking task gets a write data phase previously created by the *create_slave_transaction()* function.

The *get_write_data_phase()* sets the *data_beat_done* array *index* element field to 1 when the phase completes. If this is the last phase (beat) of the burst, then it returns the transaction *last* argument set to 1 to indicate the whole burst is complete.

**Note**

For AXI3, the *get_write_data_phase()* also sets the *WREADY* protocol signal at the appropriate time, defined by the transaction record *data_ready_delay* field.

**Prototype**

```
// * = axi | axi4
task automatic get_write_data_phase
(
   *_transaction trans,
   int index = 0, // Optional
   output bit last
);
```

**Arguments**

| | |
|---|---|
| trans | The **_transaction* record. |
| index | (Optional) Data phase (beat) number. |

**Returns**

| | |
|---|---|
| last | Flag to indicate that this data phase is the last in the burst. |

## AXI3 Example

```
// Declare a local variable to hold the transaction record.
axi_transaction write_trans;

// Create a slave transaction and assign it to the local
// write_trans variable.
write_trans = bfm.create_slave_transaction();

....

// Get the write data phase for the first beat of the
// write_trans transaction.
bfm.get_write_data_phase(write_trans, 0, last);

// Get the write data phase for the second beat of the
// write_trans transaction.
bfm.get_write_data_phase(write_trans, 1, last);
```

## AXI4 Example

```
// Declare a local variable to hold the transaction record.
axi4_transaction write_trans;

// Create a slave transaction and assign it to the local
// write_trans variable.
write_trans = bfm.create_slave_transaction();

....

// Execute the write data phase for the first beat of the
// write_trans transaction.
bfm.get_write_data_phase(write_trans, 0, last);

// Get the write data phase for the second beat of the
// write_trans transaction.
bfm.get_write_data_phase(write_trans, 1, last);
```

# get_write_data_burst()

This blocking task gets a write data burst previously created by the *create_slave_transaction()* function.

It calls the *get_write_data_phase()* task for each beat of the data burst, with the length of the burst defined by the transaction record *burst_length* field.

**Prototype**

```
// * = axi | axi4
task automatic get_write_data_burst
(
   *_transaction trans
);
```

**Arguments**

| | |
|---|---|
| trans | The **_transaction* record. |

**Returns** None

## AXI3 Example

```
// Declare a local variable to hold the transaction record.
axi_transaction write_trans;

// Create a slave transaction and assign it to the local
// write_trans variable.
write_trans = bfm.create_slave_transaction();

....

// Get the write data burst of write_trans transaction.
bfm.get_write_data_burst(write_trans);
```

## AXI4 Example

```
// Declare a local variable to hold the transaction record.
axi4_transaction write_trans;

// Create a slave transaction and assign it to the local
// write_trans variable.
write_trans = bfm.create_slave_transaction();

....

// Get the write data burst of the write_trans transaction.
bfm.get_write_data_burst(write_trans);
```

# get_read_addr_cycle()

This blocking AXI4 task waits until the read address channel *ARVALID* signal is asserted.

**Prototype** `task automatic get_read_addr_cycle();`
**Arguments** None
**Returns** None

## AXI3 BFM

**Note**
The *get_read_addr_cycle()* task is not available in the AXI3 BFM.

## AXI4 Example

```
// Waits until the read address channel ARVALID signal is asserted.
bfm.get_read_addr_cycle();
```

# execute_read_addr_ready()

This AXI4 task executes a read address ready by placing the *ready* argument value onto the A*RREADY* signal. It will block for one *ACLK* period.

**Prototype**

```
task automatic execute_read_addr_ready
(
   bit ready
);
```

**Arguments**

| | |
|---|---|
| ready | The value to be placed onto the *ARREADY* signal. |

**Returns** None

## AXI3 BFM

**Note**

The *execute_read_addr_ready()* task is not available in the AXI3 BFM. Use the *get_read_addr_phase()* task along with the transaction record *address_ready_delay* field.

## AXI4 Example

```
// Assert and deassert the ARREADY signal
forever begin
   bfm.execute_read_addr_ready(1'b0);

   bfm.wait_on(AXI4_CLOCK_POSEDGE);
   bfm.wait_on(AXI4_CLOCK_POSEDGE);

   bfm.execute_read_addr_ready(1'b1);

   bfm.wait_on(AXI4_CLOCK_POSEDGE);
end
```

# get_read_data_ready()

This blocking AXI4 task returns the read data ready value of the *RREADY* signal using the *ready* argument. It will block for one *ACLK* period.

**Prototype**

```
task automatic get_read_data_ready
(
   output bit ready
);
```

**Arguments** ready — The value of the *RREADY* signal.

**Returns** ready

## AXI3 BFM

**Note**

The *get_read_data_ready()* task is not available in the AXI3 BFM.

## AXI4 Example

```
// Get the value of the RREADY signal
bfm.get_read_data_ready();
```

# get_write_addr_cycle()

This blocking AXI4 task waits until the write address channel *AWVALID* signal is asserted.

**Prototype** `task automatic get_write_addr_cycle();`
**Arguments** None
**Returns** None

## AXI3 BFM

**Note**
The *get_write_addr_cycle()* task is not available in the AXI3 BFM.

## AXI4 Example

```
// Wait for a single write address cycle
bfm.get_write_addr_cycle();
```

# execute_write_addr_ready()

This AXI4 task executes a write address ready by placing the *ready* argument value onto the A*WREADY* signal. It will block for one *ACLK* period.

**Prototype**

```
task automatic execute_write_addr_ready
(
   bit ready
);
```

**Arguments**

| | |
|---|---|
| ready | The value to be placed onto the *AWREADY* signal |

**Returns** None

## AXI3 BFM

**Note**

The *execute_write_addr_ready()* task is not available in the AXI3 BFM. Use the *get_write_addr_phase()* task along with the transaction record *address_ready_delay* field.

## AXI4 Example

```
// Assert and deassert the AWREADY signal
forever begin
   bfm.execute_write_addr_ready(1'b0);

   bfm.wait_on(AXI4_CLOCK_POSEDGE);
   bfm.wait_on(AXI4_CLOCK_POSEDGE);

   bfm.execute_write_addr_ready(1'b1);

   bfm.wait_on(AXI4_CLOCK_POSEDGE);
end
```

# get_write_data_cycle()

This blocking AXI4 task waits for a single write data cycle for which the *WVALID* signal is asserted. It will block for one *ACLK* period.

**Prototype** `task automatic get_write_data_cycle();`
**Arguments** None
**Returns** None

## AXI3 BFM

**Note**
The *get_write_data_cycle()* task is not available in the AXI3 BFM.

## AXI4 Example

```
// Wait for a single write data cycle
bfm.get_write_data_cycle();
```

# execute_write_data_ready()

This AXI4 task executes a write data ready by placing the *ready* argument value onto the *WREADY* signal. It will block for one *ACLK* period.

**Prototype**

```
task automatic execute_write_data_ready
(
   bit ready
);
```

**Arguments** ready — The value to be placed onto the *WREADY* signal

**Returns** None

## AXI3 BFM

**Note**

The *execute_write_data_ready()* task is not available in the AXI3 BFM. Use the *get_write_data_phase()* task along with the transaction record *data_ready_delay* field.

## AXI4 Example

```
// Assert and deassert the WREADY signal
forever begin
   bfm.execute_write_data_ready(1'b0);

   bfm.wait_on(AXI4_CLOCK_POSEDGE);
   bfm.wait_on(AXI4_CLOCK_POSEDGE);

   bfm.execute_write_data_ready(1'b1);

   bfm.wait_on(AXI4_CLOCK_POSEDGE);
end
```

# get_write_resp_ready()

This blocking AXI4 task returns the write response ready value of the *BREADY* signal using the *ready* argument. It will block for one *ACLK* period.

**Prototype**

```
task automatic get_write_resp_ready
(
   output bit ready
);
```

**Arguments** ready — The value of the *BREADY* signal.

**Returns** readyt

## AXI3 BFM

**Note**

The *get_write_resp_ready()* task is not available in the AXI3 BFM.

## AXI4 Example

```
// Get the value of the BREADY signal
bfm.get_write_resp_ready();
```

# wait_on()

This blocking task waits for an event on the *ACLK* or *ARESETn* signals to occur before proceeding. An optional *count* argument waits for the number of events equal to *count*.

**Prototype**

```
// * = axi | axi4
// ** = AXI| AXI4
task automatic wait_on
(
   *_wait_e phase,
   input int count = 1 //Optional
);
```

**Arguments**

| | |
|---|---|
| phase | Wait for:<br>**_CLOCK_POSEDGE<br>**_CLOCK_NEGEDGE<br>**_CLOCK_ANYEDGE<br>**_CLOCK_0_TO_1<br>**_CLOCK_1_TO_0<br>**_RESET_POSEDGE<br>**_RESET_NEGEDGE<br>**_RESET_ANYEDGE<br>**_RESET_0_TO_1<br>**_RESET_1_TO_0 |
| count | (Optional) Wait for a number of events to occur set by *count*. (default = 1) |

**Returns** None

## AXI3 Example

```
bfm.wait_on(AXI_RESET_POSEDGE);
bfm.wait_on(AXI_CLOCK_POSEDGE,10);
```

## AXI4 Example

```
bfm.wait_on(AXI4_RESET_POSEDGE);
bfm.wait_on(AXI4_CLOCK_POSEDGE,10);
```

# Helper Functions

AMBA AXI protocols typically provide a start address only in a transaction, with the following addresses for each byte of a data burst calculated using the size, length, and type transaction fields of the transaction. Helper functions are available to provide you with a simple interface to set and get address/data values.

## get_write_addr_data()

This nonblocking function returns the actual address *addr* and *data* of a particular byte in a write data burst. It also returns the maximum number of bytes (*dynamic_size*) in the write data phase (beat). It is used in a slave test program as a helper function to store a byte of data at a particular address in the slave memory. If the corresponding *index* does not exist, then this function returns *false*, otherwise it returns *true*.

**Prototype**

```
// * = axi | axi4
// ** = AXI | AXI4
function bit get_write_addr_data
(
   input *_transaction trans,
   input int index = 0,
   output bit [((**_ADDRESS_WIDTH) - 1): 0] addr[],
   output bit [7:0] data[]
);
```

**Arguments**

| | |
|---|---|
| trans | The **_transaction* record. |
| index | Data words array element number. |

**Returns**

| | |
|---|---|
| addr | Write address. |
| data | Write data byte. |
| bit | Flag to indicate existence of *data* at *index* array element number;<br>0 = array element nonexistent.<br>1 = array element exists. |

## Example

```
bfm.get_write_addr_data(write_trans, 1, addr, data);
```

# get_read_addr()

This nonblocking function returns the address *addr* of a particular byte in a read transaction. It is used in a slave test program as a helper function to return the address of a data byte in the slave memory. If the corresponding *index* does not exist, then this function returns *false*, otherwise it returns *true*.

**Prototype**

```
// * = axi | axi4
// ** = AXI | AXI4
function bit get_read_addr
(
   input *_transaction trans,
   input int index = 0,
   output bit [((**_ADDRESS_WIDTH) - 1) : 0] addr[]
);
```

**Arguments**

| | |
|---|---|
| trans | The **_transaction* record. |
| index | Array element number |
| addr | Read address array |

**Returns**

| | |
|---|---|
| bit | Flag to indicate existence of data at *index* array element number;<br>0 = nonexistent.<br>1 = exists. |

## Example

```
bfm.get_read_addr(read_trans, 1, addr);
```

# set_read_data()

This nonblocking function sets a read data in the **_transaction* record *data_words* field. It is used in a slave test program as a helper function to read from the slave memory given the address *addr,* data beat *index*, and the read *data* arguments.

**Prototype**

```
// * = axi | axi4
// ** = AXI | AXI4
function bit set_read_data
(
   input *_transaction trans,
   input int index = 0,
   input bit [((**_ADDRESS_WIDTH) - 1) : 0] addr[],
   input bit [7:0] data[]
);
```

**Arguments**

| | |
|---|---|
| trans | The **_transaction* record. |
| index | (Optional) Data byte array element number |
| addr | Read address. |
| data | Read data byte. |

**Returns** None

## Example

```
bfm.set_read_data(read_trans, 1, addr, data);
```

# Chapter 5
# SystemVerilog AXI3 and AXI4 Monitor BFMs

This section provides information about the SystemVerilog AXI3 and AXI4 monitor BFMs. Each BFM has an API that contains tasks and functions to configure the BFM and to access the dynamic Transaction Record during the lifetime of a transaction.

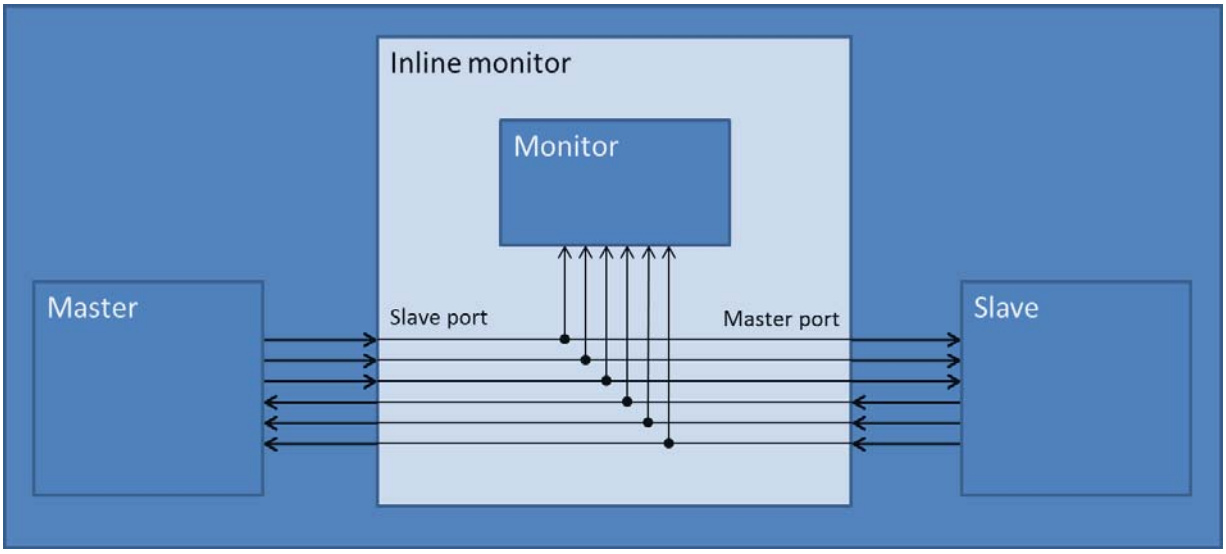
**Note**

Due to AXI3 protocol specification changes, for some BFM tasks, you reference the AXI3 interface by specifying AXI instead of AXI3.

## Inline Monitor Connection

The connection of a monitor BFM to a test environment differs from that of a master and slave BFM. It is wrapped in an inline monitor interface and connected inline between a master and slave, as shown in Figure 5-1. It has separate master and slave ports and monitors protocol traffic between a master and slave. The monitor itself then has access to all the facilities provided by the monitor BFM.

**Figure 5-1. Inline Monitor Connection Diagram**



# Monitor BFM Protocol Support

The AXI3 monitor BFM supports the AMBA AXI3 protocol with restrictions described in "Protocol Restrictions" on page 1. In addition to the standard protocol, it supports user sideband signals *AWUSER* and *ARUSER*.

The AXI4 monitor BFM supports the AMBA AXI4 protocol with restrictions described in "Protocol Restrictions" on page 1.

# Monitor Timing and Events

For detailed timing diagrams of the protocol bus activity refer to the relevant AMBA AXI Protocol Specification chapter, which you can use to reference details of the following monitor BFM API timing and events.

The specification does not define any timescale or clock period with signal events sampled and driven at rising *ACLK* edges. Therefore, the monitor BFM does not contain any timescale, timeunit, or timeprecision declarations with the signal setup and hold times specified in units of simulator time-steps.

The simulator time-step resolves to the smallest of all the time-precision declarations in the testbench and design IP as a result of:

- ` timescale directives in design elements.
- timeprecision declarations in design elements.
- compiler command-line options.
- simulation command-line options.
- local or site-wide simulator initialization files.

If there is no timescale directive, the default time unit and time precision are tool specific.The recommended practice is to use timeunit and timeprecision declarations. Refer to the SystemVerilog LRM section 3.14 for details.

# Monitor BFM Configuration

The monitor BFM supports the full range of signals defined for the AMBA AXI protocol specification. It has parameters that can be used to configure the widths of the address, data and ID signals and transaction fields to configure timeout factors, slave exclusive support, setup and hold times, etc.

The address, data and ID signals widths can be changed from their default settings by assigning them with new values, usually performed in the top-level module of the testbench. These new values are then passed into the monitor BFM via a parameter port list of the monitor BFM

module. For example, the code extract below shows the AXI3 monitor BFM with the address, data and ID signal widths defined in *module top()* and passed in to the monitor BFM *mgc_axi_monitor* parameter port list:

```
module top ();

   parameter AXI_ADDRESS_WIDTH = 24;
   parameter AXI_RDATA_WIDTH = 16;
   parameter AXI_WDATA_WIDTH = 16;
   parameter AXI_ID_WIDTH = 4;

   mgc_axi_monitor #(AXI_ADDRESS_WIDTH, AXI_RDATA_WIDTH, AXI_WDATA_WIDTH,
AXI_ID_WIDTH) bfm_monitor(....);
```

**Note**

In the above code extract the *mgc_axi_monitor* is the AXI3 monitor BFM interface.

The following table lists the parameter names for the address, data and ID signals and their default values.

**Table 5-1. AXI Monitor BFM Signal Width Parameters**

| Signal Width Parameter | Description |
|---|---|
| **_ADDRESS_WIDTH | Address signal width in bits. This applies to the *ARADDR* and *AWADDR* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 64. |
| **_RDATA_WIDTH | Read data signal width in bits. This applies to the *RDATA* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 1024. |
| **_WDATA_WIDTH | Write data signal width in bits. This applies to the *WDATA* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 1024. |
| **_ID_WIDTH | IID signal width in bits. This applies to the *RID* and *WID* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 18. |
| AXI4_USER_WIDTH | (AXI4) User data signal width in bits. This applies to the *ARUSER*, *AWUSER*, *RUSER*, *WUSER* and *BUSER* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 8. |
| AXI4_REGION_MAP_SIZE | (AXI4) Region signal width in bits. This applies to the *ARREGION* and *AWREGION* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 16. |

A monitor BFM has configuration fields that you can set via the *set_config()* function to configure timeout factors, slave exclusive support, setup and hold times, etc. You can also get

the value of a configuration field via the *get_config()* function. The full list of configuration fields is described in the table below.

**Table 5-2. AXI Monitor BFM Configuration**

| Configuration Field | Description |
|---|---|
| **Timing Variables** | |
| **_CONFIG_SETUP_TIME | The setup-time prior to the active edge of *ACLK*, in units of simulator time-steps for all signals.[1] Default: 0. |
| **_CONFIG_HOLD_TIME | The hold-time after the active edge of *ACLK*, in units of simulator time-steps for all signals.[1] Default: 0. |
| AXI_CONFIG_MAX_TRANSACTION_TIME_FACTOR | (AXI3) The maximum timeout duration for a read/write transaction in clock cycles. Default: 100000. |
| **_CONFIG_BURST_TIMEOUT_FACTOR | The maximum delay between the individual phases of a read/write transaction in clock cycles. Default: 10000. |
| AXI4_CONFIG_MAX_LATENCY_AWVALID_ ASSERTION_TO_AWREADY | (AXI4) The maximum timeout duration from the assertion of *AWVALID* to the assertion of *AWREADY* in clock periods (default 10000). |
| AXI4_CONFIG_MAX_LATENCY_ARVALID_ ASSERTION_TO_ARREADY | (AXI4) The maximum timeout duration from the assertion of *ARVALID* to the assertion of *ARREADY* in clock periods (default 10000). |
| AXI4_CONFIG_MAX_LATENCY_RVALID_ ASSERTION_TO_RREADY | (AXI4) The maximum timeout duration from the assertion of *RVALID* to the assertion of *RREADY* in clock periods (default 10000). |
| AXI4_CONFIG_MAX_LATENCY_BVALID_ ASSERTION_TO_BREADY | (AXI4) The maximum timeout duration from the assertion of *BVALID* to the assertion of *BREADY* in clock periods (default 10000). |
| AXI4_CONFIG_MAX_LATENCY_WVALID_ ASSERTION_TO_WREADY | (AXI4) The maximum timeout duration from the assertion of *WVALID* to the assertion of *WREADY* in clock periods (default 10000). |
| **Master Attributes** | |
| AXI_CONFIG_WRITE_CTRL_TO_DATA_MINTIME | (AXI3) The minimum delay from the start of a write control (address) phase to the start of a write data phase in clock cycles. Default: 1. |

**Table 5-2. AXI Monitor BFM Configuration**

| Configuration Field | Description |
|---|---|
| **Master Attributes** | |
| AXI_CONFIG_MASTER_WRITE_DELAY | (AXI3) The master BFM applies the AXI_CONFIG_WRITE_CTRL_TO_DATA_MINTIME value set.<br>0 = true (default)<br>1 = false |
| AXI_CONFIG_MASTER_DEFAULT_UNDER_RESET | (AXI3) The master BFM drives the *ARVALID*, *AWVALID* and *WVALID* signals low during reset:<br>0 = false (default)<br>1 = true |
| AXI4_CONFIG_ENABLE_QOS | (AXI4) The master participates in the Quality-of-Service (qos) scheme. If a master does not participate, the *AWQOS/ARQOS* value used in write/read transactions must be b0000. |
| **Slave Attributes** | |
| **_CONFIG_SUPPORT_EXCLUSIVE_ACCESS | Configures the support for an exclusive slave. If enabled the BFM will expect an *EXOKAY* response to a successful exclusive transaction. If disabled the BFM will expect an *OKAY* response to an exclusive transaction. Refer to the AMBA AXI protocol specification for more details.<br>0 = disabled<br>1 = enabled (default) |
| AXI_CONFIG_SLAVE_DEFAULT_UNDER_RESET | (AXI3) The slave BFM drives the *BVALID* and *RVALID* signals low during reset. Refer to the AMBA AXI Protocol specification for more details.<br>0 = false (default)<br>1 = true |
| AXI4_CONFIG_SLAVE_START_ADDR | (AXI4) Configures the start address map for the slave. |
| AXI4_CONFIG_SLAVE_END_ADDR | (AXI4) Configures the end address map for the slave. |
| AXI4_CONFIG_READ_DATA_REORDERING_DEPTH | (AXI4) The slave read reordering depth. Refer to the AMBA AXI Protocol specification for more details. Default: 1. |
| **Error Detection** | |
| **_CONFIG_ENABLE_ALL_ASSERTIONS | Global enable/disable of all assertion checks in the BFM.<br>0 = disabled<br>1 = enabled (default) |

[1] Refer to Monitor Timing and Events for details of simulator time-steps.

# Monitor Assertions

Each monitor BFM performs protocol error checking via built-in assertions.

**Note**
The built-in BFM assertions are independent of programming language and simulator.

## AXI3 Assertion Configuration

By default, all built-in assertions are enabled in the monitor BFM. To globally disable them in the monitor BFM, use the *set_config()* command as the following example illustrates:

```
set_config(AXI_CONFIG_ENABLE_ALL_ASSERTIONS,0)
```

Alternatively, individual built-in assertions can be disabled by using a sequence of *get_config()* and *set_config()* commands on the respective assertion. For example, to disable assertion checking for the *AWLOCK* signal changing between the *AWVALID* and *AWREADY* handshake signals, use the following sequence of commands:

```
// Define a local bit vector to hold the value of the assertion bit vector
bit [255:0] config_assert_bitvector;

// Get the current value of the assertion bit vector
config_assert_bitvector = bfm.get_config(AXI_CONFIG_ENABLE_ASSERTION);

// Assign the AXI_LOCK_CHANGED_BEFORE_AWREADY assertion bit to 0
config_assert_bitvector[AXI_LOCK_CHANGED_BEFORE_AWREADY] = 0;

// Set the new value of the assertion bit vector
bfm.set_config(AXI_CONFIG_ENABLE_ASSERTION, config_assert_bitvector);
```

**Note**
Do not confuse the *AXI_CONFIG_ENABLE_ASSERTION* bit vector with the *AXI_CONFIG_ENABLE_ALL_ASSERTIONS* global enable/disable.

To re-enable the *AXI_LOCK_CHANGED_BEFORE_AWREADY* assertion, follow the above code sequence and assign the assertion in the *AXI_CONFIG_ENABLE_ASSERTION* bit vector to 1.

For a complete listing of AXI3 assertions, refer to "AXI3 Assertions" on page 641.

## AXI4 Assertion Configuration

By default, all built-in assertions are enabled in the monitor AXI4 BFM. To globally disable them in the monitor BFM, use the *set_config()* command as the following example illustrates:

```
set_config(AXI4_CONFIG_ENABLE_ALL_ASSERTIONS,0)
```

Alternatively, individual built-in assertions can be disabled by using a sequence of *get_config()* and *set_config()* commands on the respective assertion. For example, to disable assertion checking for the *AWLOCK* signal changing between the *AWVALID* and *AWREADY* handshake signals, use the following sequence of commands:

```
// Define a local bit vector to hold the value of the assertion bit vector
bit [255:0] config_assert_bitvector;

// Get the current value of the assertion bit vector
config_assert_bitvector = bfm.get_config(AXI4_CONFIG_ENABLE_ASSERTION);

// Assign the AXI4_LOCK_CHANGED_BEFORE_AWREADY assertion bit to 0
config_assert_bitvector[AXI4_LOCK_CHANGED_BEFORE_AWREADY] = 0;

// Set the new value of the assertion bit vector
bfm.set_config(AXI4_CONFIG_ENABLE_ASSERTION, config_assert_bitvector);
```

**Note**

Do not confuse the *AXI4_CONFIG_ENABLE_ASSERTION* bit vector with the *AXI4_CONFIG_ENABLE_ALL_ASSERTIONS* global enable/disable.

To re-enable the *AXI4_LOCK_CHANGED_BEFORE_AWREADY* assertion, follow the above code sequence and assign the assertion in the *AXI4_CONFIG_ENABLE_ASSERTION* bit vector to 1.

For a complete listing of AXI4 assertions, refer to "AXI4 Assertions" on page 654.

# SystemVerilog Monitor API

This section describes the SystemVerilog Monitor API.

# set_config()

This function sets the configuration of the monitor BFM

**Prototype**

```
// * = axi | axi4
function void set_config
(
   input *_config_e config_name,
   input *_max_bits_t config_val
);
```

**Arguments**

config_name

**(AXI3) Configuration name:**

AXI_CONFIG_SETUP_TIME
AXI_CONFIG_HOLD_TIME
AXI_CONFIG_MAX_TRANSACTION_TIME_FACTOR
AXI_CONFIG_TIMEOUT_MAX_DATA_TRANSFER
AXI_CONFIG_BURST_TIMEOUT_FACTOR
AXI_CONFIG_WRITE_CTRL_TO_DATA_MINTIME
AXI_CONFIG_MASTER_WRITE_DELAY
AXI_CONFIG_MASTER_DEFAULT_UNDER_RESET
AXI_CONFIG_SLAVE_DEFAULT_UNDER_RESET
AXI_CONFIG_ENABLE_ALL_ASSERTIONS
AXI_CONFIG_MASTER_ERROR_POSITION
AXI_CONFIG_SUPPORT_EXCLUSIVE_ACCESS

**(AXI4) Configuration name:**

AXI4_CONFIG_SETUP_TIME
AXI4_CONFIG_HOLD_TIME
AXI4_CONFIG_BURST_TIMEOUT_FACTOR
AXI4_CONFIG_ENABLE_RLAST
AXI4_CONFIG_ENABLE_SLAVE_EXCLUSIVE
AXI4_CONFIG_ENABLE_ALL_ASSERTIONS
AXI4_CONFIG_ENABLE_ASSERTION
AXI4_CONFIG_MAX_LATENCY_AWVALID_ASSERTION_TO_AWREADY
AXI4_CONFIG_MAX_LATENCY_ARVALID_ASSERTION_TO_ARREADY
AXI4_CONFIG_MAX_LATENCY_RVALID_ASSERTION_TO_RREADY
AXI4_CONFIG_MAX_LATENCY_BVALID_ASSERTION_TO_BREADY
AXI4_CONFIG_MAX_LATENCY_WVALID_ASSERTION_TO_WREADY
AXI4_CONFIG_ENABLE_QOS
AXI4_CONFIG_READ_DATA_REORDERING_DEPTH
AXI4_CONFIG_SLAVE_START_ADDR
AXI4_CONFIG_SLAVE_END_ADDR

config_val

See "Monitor BFM Configuration" on page 100 for descriptions and valid values.

**Returns**

None

## AXI3 Example

```
set_config(AXI_CONFIG_SUPPORT_EXCLUSIVE_ACCESS, 1);
set_config(AXI_CONFIG_BURST_TIMEOUT_FACTOR, 1000);
```

## AXI4 Example

```
set_config(AXI4_CONFIG_ENABLE_SLAVE_EXCLUSIVE, 1);
set_config(AXI4_CONFIG_BURST_TIMEOUT_FACTOR, 1000);
```

# get_config()

This function gets the configuration of the monitor BFM.

**Prototype**

```
// * = axi | axi4
function void get_config
(
   input *_config_e config_name,
);
```

**Arguments**

config_name

**(AXI3) Configuration name:**

AXI_CONFIG_SETUP_TIME
AXI_CONFIG_HOLD_TIME
AXI_CONFIG_MAX_TRANSACTION_TIME_FACTOR
AXI_CONFIG_TIMEOUT_MAX_DATA_TRANSFER
AXI_CONFIG_BURST_TIMEOUT_FACTOR
AXI_CONFIG_WRITE_CTRL_TO_DATA_MINTIME
AXI_CONFIG_MASTER_WRITE_DELAY
AXI_CONFIG_MASTER_DEFAULT_UNDER_RESET
AXI_CONFIG_SLAVE_DEFAULT_UNDER_RESET
AXI_CONFIG_ENABLE_ALL_ASSERTIONS
AXI_CONFIG_MASTER_ERROR_POSITION
AXI_CONFIG_SUPPORT_EXCLUSIVE_ACCESS

**(AXI4) Configuration name:**

AXI4_CONFIG_SETUP_TIME
AXI4_CONFIG_HOLD_TIME
AXI4_CONFIG_BURST_TIMEOUT_FACTOR
AXI4_CONFIG_ENABLE_RLAST
AXI4_CONFIG_ENABLE_SLAVE_EXCLUSIVE
AXI4_CONFIG_ENABLE_ALL_ASSERTIONS
AXI4_CONFIG_ENABLE_ASSERTION
AXI4_CONFIG_MAX_LATENCY_AWVALID_ASSERTION_TO_AWREADY
AXI4_CONFIG_MAX_LATENCY_ARVALID_ASSERTION_TO_ARREADY
AXI4_CONFIG_MAX_LATENCY_RVALID_ASSERTION_TO_RREADY
AXI4_CONFIG_MAX_LATENCY_BVALID_ASSERTION_TO_BREADY
AXI4_CONFIG_MAX_LATENCY_WVALID_ASSERTION_TO_WREADY
AXI4_CONFIG_ENABLE_QOS
AXI4_CONFIG_READ_DATA_REORDERING_DEPTH
AXI4_CONFIG_SLAVE_START_ADDR
AXI4_CONFIG_SLAVE_END_ADDR

**Returns**

config_val

See "Monitor BFM Configuration" on page 100 for descriptions and valid values.

## AXI3 Example

```
get_config(AXI_CONFIG_SUPPORT_EXCLUSIVE_ACCESS);
get_config(AXI_CONFIG_BURST_TIMEOUT_FACTOR);
```

## AXI4 Example

```
get_config(AXI4_CONFIG_ENABLE_SLAVE_EXCLUSIVE);
get_config(AXI4_CONFIG_BURST_TIMEOUT_FACTOR);
```

# create_monitor_transaction()

This non-blocking function creates a monitor transaction. All transaction fields default to legal protocol values, unless previously assigned a value. It returns with the **_transaction* record.

**Prototype**

```
// * = axi | axi4
// ** = AXI | AXI4
function automatic *_transaction create_monitor_transaction();
```

**Protocol Transaction Fields**

| | |
|---|---|
| addr | Start address |
| burst_length | (Optional) Burst length. Default: 0. |
| size | Burst size. Default: width of bus:<br>**_BYTES_1;<br>**_BYTES_2;<br>**_BYTES_4;<br>**_BYTES_8;<br>**_BYTES_16;<br>**_BYTES_32;<br>**_BYTES_64;<br>**_BYTES_128; |
| burst | Burst type:<br>**_FIXED;<br>**_INCR; (default)<br>**_WRAP;<br>**_BURST_RSVD; |
| lock | Burst lock:<br>**_NORMAL; (default)<br>**_EXCLUSIVE;<br>(AXI3) AXI_LOCKED;<br>(AXI3) AXI_LOCK_RSVD; |
| cache | (AXI3) Burst cache:<br>AXI_NONCACHE_NONBUF; (default)<br>AXI_BUF_ONLY;<br>AXI_CACHE_NOALLOC;<br>AXI_CACHE_BUF_NOALLOC;<br>AXI_CACHE_RSVD0;<br>AXI_CACHE_RSVD1;<br>AXI_CACHE_WTHROUGH_ALLOC_R_ONLY;<br>AXI_CACHE_WBACK_ALLOC_R_ONLY;<br>AXI_CACHE_RSVD2;<br>AXI_CACHE_RSVD3;<br>AXI_CACHE_WTHROUGH_ALLOC_W_ONLY;<br>AXI_CACHE_WBACK_ALLOC_W_ONLY;<br>AXI_CACHE_RSVD4;<br>AXI_CACHE_RSVD5;<br>AXI_CACHE_WTHROUGH_ALLOC_RW;<br>AXI_CACHE_WBACK_ALLOC_RW; |

| | | |
|---|---|---|
| **Protocol Transaction Fields** | cache | (AXI4) Burst cache:<br>AXI4_NONMODIFIABLE_NONBUF; (default)<br>AXI4_BUF_ONLY;<br>AXI4_CACHE_NOALLOC;<br>AXI4_CACHE_2;<br>AXI4_CACHE_3;<br>AXI4_CACHE_RSVD4;<br>AXI4_CACHE_RSVD5;<br>AXI4_CACHE_6;<br>AXI4_CACHE_7;<br>AXI4_CACHE_RSVD8;<br>AXI4_CACHE_RSVD9;<br>AXI4_CACHE_10;<br>AXI4_CACHE_11;<br>AXI4_CACHE_RSVD12;<br>AXI4_CACHE_RSVD12;<br>AXI4_CACHE_14;<br>AXI4_CACHE_15; |
| | prot | Protection:<br>**_NORM_SEC_DATA; (default)<br>**_PRIV_SEC_DATA;<br>**_NORM_NONSEC_DATA;<br>**_PRIV_NONSEC_DATA;<br>**_NORM_SEC_INST;<br>**_PRIV_SEC_INST;<br>**_NORM_NONSEC_INST;<br>**_PRIV_NONSEC_INST; |
| | id | Burst ID |
| | data_words | Data words array. |
| | write_strobes | Write strobes array:<br>Each strobe 0 or 1. |
| | resp | Burst response:<br>**_OKAY;<br>**_EXOKAY;<br>**_SLVERR;<br>**_DECERR; |
| | region | (AXI4) Region identifier. |
| | qos | (AXI4) Quality-of-Service identifier. |
| | addr_user | Address channel user data. |
| | data_user | (AXI4) Data channel user data. |
| | resp_user | (AXI4) Response channel user data. |
| **Operational Transaction Fields** | gen_write_strobes | Generate write strobes flag:<br>0 = user supplied write strobes.<br>1 = auto-generated write strobes (default). |
| | operation_mode | Operation mode:<br>**_TRANSACTION_NON_BLOCKING;<br>**_TRANSACTION_BLOCKING; (default) |
| | delay_mode | (AXI3) Delay mode:<br>AXI_VALID2READY; (default)<br>AXI_TRANS2READY; |
| | write_data_mode | Write data mode:<br>**_DATA_AFTER_ADDRESS; (default)<br>**_DATA_WITH_ADDRESS; |

| | | |
|---|---|---|
| **Operational Transaction Fields** | address_valid_delay | Address channel *AWVALID* delay measured in *ACLK* cycles for this transaction (default = 0). |
| | data_valid_delay | Write data channel *WVALID* delay array measured in *ACLK* cycles for this transaction (default = 0 for all elements). |
| | write_response_ready_delay | Write response channel *BREADY* delay measured in *ACLK* cycles for this transaction (default = 0). |
| | data_beat_done | Write data channel beat *done* flag array for this transaction. |
| | transaction_done | Write transaction *done* flag for this transaction. |
| **Returns** | The **_transaction* record | |

## Example

```
// Create a monitor transaction
trans = bfm.create_monitor_transaction();
```

# get_rw_transaction()

This blocking task gets a complete read or write transaction previously created by the *create_monitor_transaction()* function.

It updates the **_transaction* record for the complete transaction.

**Prototype**

```
// * = axi | axi4
task automatic get_rw_transaction
(
   *_transaction trans
)
```

**Arguments**

| | |
|---|---|
| trans | The **_transaction* record. |

**Returns** None

## AXI3 Example

```
// Declare a local variable to hold the transaction record.
axi_transaction monitor_trans;

// Create a monitor transaction and assign it to the local
// monitor_trans variable.
monitor_trans = bfm.create_monitor_transaction();

....

// Get the complete monitor_trans transaction.
bfm.get_rw_transaction(monitor_trans);
```

## AXI4 Example

```
// Declare a local variable to hold the transaction record.
axi4_transaction monitor_trans;

// Create a monitor transaction and assign it to the local
// monitor_trans variable.
monitor_trans = bfm.create_monitor_transaction();

....

// Get the complete monitor_trans transaction.
bfm.get_rw_transaction(monitor_trans);
```

# get_write_addr_phase()

This blocking task gets a write address phase previously created by the *create_monitor_transaction()* function.

**Prototype**

```
// * = axi | axi4
task automatic get_write_addr_phase
(
   *_transaction trans
);
```

**Arguments** trans — The **_transaction* record.

**Returns** None

## AXI3 Example

```
// Declare a local variable to hold the transaction record.
axi_transaction write_trans;

// Create a monitor transaction and assign it to the local
// write_trans variable.
write_trans = bfm.create_monitor_transaction();

....

// Get the write address phase of the write_trans transaction.
bfm.get_write_addr_phase(write_trans);
```

## AXI4 Example

```
// Declare a local variable to hold the transaction record.
axi4_transaction write_trans;

// Create a monitor transaction and assign it to the local
// write_trans variable.
write_trans = bfm.create_monitor_transaction();

....

// Get the write address phase of the write_trans transaction.
bfm.get_write_addr_phase(write_trans);
```

# get_read_addr_phase()

This blocking task gets a read address phase previously created by the *create_monitor_transaction()* function.

**Prototype**

```
// * = axi | axi4
task automatic get_read_addr_phase
(
   *_transaction trans
);
```

**Arguments** trans — The **_transaction* record.

**Returns** None

## AXI3 Example

```
// Declare a local variable to hold the transaction record.
axi_transaction read_trans;

// Create a monitor transaction and assign it to the local
// read_trans variable.
read_trans = bfm.create_monitor_transaction();

....

// Get the read address phase of the read_trans transaction.
bfm.get_read_addr_phase(read_trans);
```

## AXI4 Example

```
// Declare a local variable to hold the transaction record.
axi4_transaction read_trans;

// Create a monitor transaction and assign it to the local
// read_trans variable.
read_trans = bfm.create_monitor_transaction();

....

// Get the read address phase of the read_trans transaction.
bfm.get_read_addr_phase(read_trans);
```

# get_read_data_phase()

This blocking task gets a read data phase previously created by the *create_monitor_transaction()* function.

The *get_read_data_phase()* sets the *data_beat_done* array *index* element field to 1 when the phase completes. If this is the last phase (beat) of the burst, then it sets the *transaction_done* field to 1 to indicate the whole read transaction is complete.

**Prototype**

```
// * = axi | axi4
task automatic get_read_data_phase
(
   *_transaction trans,
   int index = 0 // Optional
);
```

**Arguments**

| | |
|---|---|
| trans | The **_transaction* record. |
| index | (Optional) Data phase (beat) number. |

**Returns** None

## AXI3 Example

```
// Declare a local variable to hold the transaction record.
axi_transaction read_trans;

// Create a monitor transaction and assign it to the local
// read_trans variable.
read_trans = bfm.create_monitor_transaction();

....

// Get the read data phase for the first beat of the
// read_trans transaction.
bfm.get_read_data_phase(read_trans, 0);

// Get the read data phase for the second beat of the
// read_trans transaction.
bfm.get_read_data_phase(read_trans, 1);
```

## AXI4 Example

```
// Declare a local variable to hold the transaction record.
axi4_transaction read_trans;

// Create a monitor transaction and assign it to the local
// read_trans variable.
read_trans = bfm.create_monitor_transaction();

....

// Execute the read data phase for the first beat of the
// read_trans transaction.
bfm.get_read_data_phase(read_trans, 0);

// Get the read data phase for the second beat of the
// read_trans transaction.
bfm.get_read_data_phase(read_trans, 1);
```

# get_read_data_burst()

This blocking task gets a read data burst previously created by the *create_monitor_transaction()* function.

It calls the *get_read_addr_ready()* task for each beat of the data burst, with the length of the burst defined by the transaction record *burst_length* field.

**Prototype**

```
// * = axi | axi4
task automatic get_read_data_burst
(
   *_transaction trans
);
```

**Arguments**

| | |
|---|---|
| trans | The **_transaction* record. |

**Returns** None

## AXI3 Example

```
// Declare a local variable to hold the transaction record.
axi_transaction read_trans;

// Create a monitor transaction and assign it to the local
// read_trans variable.
read_trans = bfm.create_monitor_transaction();

....

// Get the read data burst of read_trans transaction.
bfm.get_read_data_burst(read_trans);
```

## AXI4 Example

```
// Declare a local variable to hold the transaction record.
axi4_transaction read_trans;

// Create a monitor transaction and assign it to the local
// read_trans variable.
read_trans = bfm.create_monitor_transaction();

....

// Get the read data burst of the read_trans transaction.
bfm.get_read_data_burst(read_trans);
```

# get_write_data_phase()

This blocking task gets a write data phase previously created by the *create_monitor_transaction()* function.

The *get_write_data_phase()* sets the *data_beat_done* array *index* element field to 1 when the phase completes. If this is the last phase (beat) of the burst, then it returns the transaction *last* argument set to 1 to indicate the whole burst is complete.

**Prototype**

```
// * = axi | axi4
task automatic get_write_data_phase
(
   *_transaction trans,
   int index = 0, // Optional
   output bit last
);
```

**Arguments**

| | |
|---|---|
| trans | The **_transaction* record. |
| index | (Optional) Data phase (beat) number. |

**Returns**

| | |
|---|---|
| last | Flag to indicate that this data phase is the last in the burst. |

## AXI3 Example

```
// Declare a local variable to hold the transaction record.
axi_transaction write_trans;

// Create a monitor transaction and assign it to the local
// write_trans variable.
write_trans = bfm.create_monitor_transaction();

....

// Get the write data phase for the first beat of the
// write_trans transaction.
bfm.get_write_data_phase(write_trans, 0, last);

// Get the write data phase for the second beat of the
// write_trans transaction.
bfm.get_write_data_phase(write_trans, 1, last);
```

## AXI4 Example

```
// Declare a local variable to hold the transaction record.
axi4_transaction write_trans;

// Create a monitor transaction and assign it to the local
// write_trans variable.
write_trans = bfm.create_monitor_transaction();

....

// Execute the write data phase for the first beat of the
// write_trans transaction.
bfm.get_write_data_phase(write_trans, 0, last);

// Get the write data phase for the second beat of the
// write_trans transaction.
bfm.get_write_data_phase(write_trans, 1, last);
```

# get_write_data_burst()

This blocking task gets a write data burst previously created by the *create_monitor_transaction()* function.

It calls the *get_read_data_phase()* task for each beat of the data burst, with the length of the burst defined by the transaction record *burst_length* field.

**Prototype**

```
// * = axi | axi4
task automatic get_write_data_burst
(
   *_transaction trans
);
```

**Arguments** trans — The **_transaction* record.

**Returns** None

## AXI3 Example

```
// Declare a local variable to hold the transaction record.
axi_transaction write_trans;

// Create a monitor transaction and assign it to the local
// write_trans variable.
write_trans = bfm.create_monitor_transaction();

....

// Get the write data burst of write_trans transaction.
bfm.get_write_data_burst(write_trans);
```

## AXI4 Example

```
// Declare a local variable to hold the transaction record.
axi4_transaction write_trans;

// Create a monitor transaction and assign it to the local
// write_trans variable.
write_trans = bfm.create_monitor_transaction();

....

// Get the write data burst of the write_trans transaction.
bfm.get_write_data_burst(write_trans);
```

# get_write_response_phase

This blocking task gets a write response phase previously created by the *create_monitor_transaction()* task.

It sets the *transaction_done* field to 1 when the transaction completes to indicate the whole transaction is complete

**Prototype**

```
// * = axi | axi4
task automatic get_write_response_phase
(
   *_transaction trans
);
```

**Arguments** trans — The **_transaction* record.

**Returns** None

## AXI3 Example

```
// Declare a local variable to hold the transaction record.
axi_transaction write_trans;

// Create a monitor transaction and assign it to the local
// write_trans variable.
write_trans = bfm.create_monitor_transaction();

....

// Get the write response phase of the write_trans transaction.
bfm.get_write_response_phase(write_trans);
```

## AXI4 Example

```
// Declare a local variable to hold the transaction record.
axi4_transaction write_trans;

// Create a monitor transaction and assign it to the local
// write_trans variable.
write_trans = bfm.create_monitor_transaction();

....

// Get the write response phase of the write_trans transaction.
bfm.get_write_response_phase(write_trans);
```

# get_read_addr_ready()

This blocking AXI4 task returns the read address ready value of the *ARREADY* signal using the *ready* argument. It will block for one *ACLK* period.

**Prototype**

```
task automatic get_read_addr_ready
(
   output bit ready
);
```

**Arguments** ready — The value of the *ARREADY* signal.

**Returns** None

## AXI3 BFM

**Note**

The *get_read_addr_ready()* task is not available in the AXI3 BFM.

## AXI4 Example

```
// Get the ARREADY signal value
bfm.get_read_addr_ready();
```

# get_read_data_ready()

This blocking AXI4 task returns the read data ready value of the *RREADY* signal using the *ready* argument. It will block for one *ACLK* period.

**Prototype**

```
task automatic get_read_data_ready
(
   output bit ready
);
```

**Arguments** ready — The value of the *RREADY* signal.

**Returns** None

## AXI3 BFM

**Note**

The *get_read_data_ready()* task is not available in the AXI3 BFM.

## AXI4 Example

```
// Get the value of the RREADY signal
bfm.get_read_data_ready();
```

# get_write_addr_ready()

This blocking AXI4 task returns the write address ready value of the *AWREADY* signal using the *ready* argument. It will block for one *ACLK* period.

**Prototype**

```
task automatic get_write_addr_ready
(
   output bit ready
);
```

**Arguments** ready — The value of the A*WREADY* signal.

**Returns** None

## AXI3 BFM

**Note**

The *get_write_addr_ready()* task is not available in the AXI3 BFM.

## AXI4 Example

```
// Get the value of the AWREADY signal
bfm.get_write_addr_ready();
```

# get_write_data_ready()

This blocking AXI4 task returns the write data ready value of the *WREADY* signal using the *ready* argument. It will block for one *ACLK* period.

**Prototype**

```
task automatic get_write_data_ready
(
   output bit ready
);
```

**Arguments** ready — The value of the *WREADY* signal.

**Returns** None

## AXI3 BFM

**Note**

The *get_write_data_ready()* task is not available in the AXI3 BFM.

## AXI4 Example

```
// Get the value of the WREADY signal
bfm.get_write_data_ready();
```

# get_write_resp_ready()

This blocking AXI4 task returns the write response ready value of the *BREADY* signal using the *ready* argument. It will block for one *ACLK* period.

**Prototype**

```
task automatic get_write_resp_ready
(
   output bit ready
);
```

**Arguments** ready — The value of the *BREADY* signal.

**Returns** None

## AXI3 BFM

**Note**

The *get_write_resp_ready()* task is not available in the AXI3 BFM.

## AXI4 Example

```
// Get the value of the BREADY signal
bfm.get_write_resp_ready();
```

# wait_on()

This blocking task waits for an event(s) on the *ACLK* or *ARESETn* signals to occur before proceeding. An optional *count* argument waits for the number of events equal to *count*

**Prototype**

```
// * = axi | axi4
// ** = AXI| AXI4
task automatic wait_on
(
   *_wait_e phase,
   input int count = 1 //Optional
);
```

**Arguments**

| | |
|---|---|
| phase | Wait for:<br>**_CLOCK_POSEDGE<br>**_CLOCK_NEGEDGE<br>**_CLOCK_ANYEDGE<br>**_CLOCK_0_TO_1<br>**_CLOCK_1_TO_0<br>**_RESET_POSEDGE<br>**_RESET_NEGEDGE<br>**_RESET_ANYEDGE<br>**_RESET_0_TO_1<br>**_RESET_1_TO_0 |
| count | (Optional) Wait for a number of events to occur set by *count*. (default = 1) |

**Returns** None

## AXI3 Example

```
bfm.wait_on(AXI_RESET_POSEDGE);
bfm.wait_on(AXI_CLOCK_POSEDGE,10);
```

## AXI4 Example

```
bfm.wait_on(AXI4_RESET_POSEDGE);
bfm.wait_on(AXI4_CLOCK_POSEDGE,10);
```

# Helper Functions

AMBA AXI protocols typically provide a start address only in a transaction, with the following addresses for each byte of a data burst calculated using the size, length, and type transaction fields. Helper functions provide you with a simple interface to set and get address/data values.

## get_write_addr_data()

This nonblocking function returns the actual address *addr* and *data* of a particular byte in a write data burst. It is used in a monitor test program as a helper function to store a byte of data at a particular address in the monitor memory. If the corresponding *index* does not exist, then this function returns *false*, otherwise it returns *true*.

**Prototype**

```
// * = axi | axi4
// ** = AXI | AXI4
function bit get_write_addr_data
(
   input *_transaction trans,
   input int index = 0,
   output bit [((**_ADDRESS_WIDTH) - 1) : 0] addr[],
   output bit [7:0] data[]
);
```

**Arguments**

| | |
|---|---|
| trans | The **_transaction* record. |
| index | Array element number |
| addr | Write address array |
| data | Write data array |

**Returns**

| | |
|---|---|
| bit | Flag to indicate existence of *index* array element;<br>0 = array element non-existent.<br>1 = array element exists. |

## Example

```
bfm.get_write_addr_data(write_trans, 1, addr, data);
```

# get_read_addr()

This nonblocking function returns the actual address *addr* of a particular index in a read transaction. It is used in a monitor test program as a helper function to return the address of a byte of data in the monitor memory. If the corresponding *index* does not exist, then this function returns *false*, otherwise it returns *true*.

**Prototype**

```
// * = axi | axi4
// ** = AXI | AXI4
function bit get_read_addr
(
   input *_transaction trans,
   input int index = 0,
   output bit [((**_ADDRESS_WIDTH) - 1) : 0] addr[]
);
```

**Arguments**

| | |
|---|---|
| trans | The **_transaction* record. |
| index | Array element number |
| addr | Read address array |

**Returns**

| | |
|---|---|
| bit | Flag to indicate existence of *index* array element;<br>0 = array element non-existent.<br>1 = array element exists. |

## Example

```
bfm.get_read_addr(read_trans, 1, addr);
```

# set_read_data()

This nonblocking function sets the read data in the **_transaction* record *data_words* field. It is used in a monitor test program as a helper function to read from the monitor memory given the address *addr,* data beat *index*, and the read *data* arguments.

**Prototype**

```
// * = axi | axi4
// ** = AXI | AXI4
function bit set_read_addr_data
(
   input *_transaction trans,
   input int index = 0,
   input bit [((**_ADDRESS_WIDTH) - 1) : 0] addr[],
   input bit [7:0] data[]
);
```

**Arguments**

| | |
|---|---|
| trans | The **_transaction* record. |
| index | (Optional) Array element number |
| addr | Read address array |
| data | Read data array |

**Returns** None

## Example

```
bfm.set_read_data(read_trans, 1, addr, data);
```

# Chapter 6
# SystemVerilog Tutorials

This chapter discusses how to use the Mentor Verification IP Altera Edition master and slave BFMs to verify slave and master DUT components.

In the Verifying a Slave DUT tutorial the slave is an on-chip RAM model that is verified using a master BFM and test program.

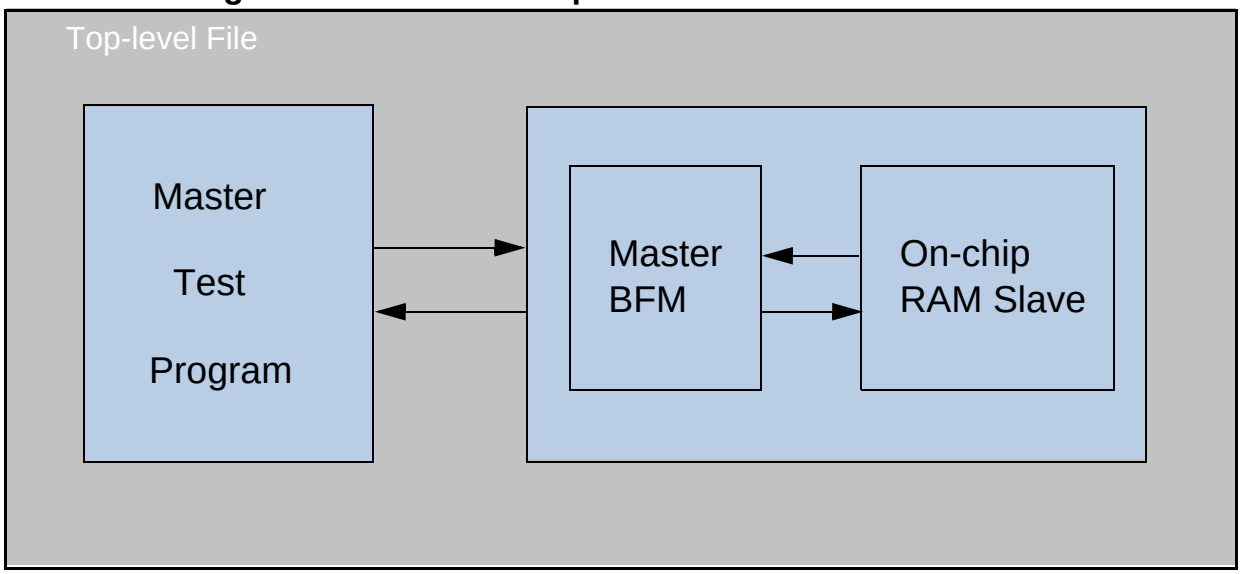
In the Verifying a Master DUT tutorial the master issues simple write and read transactions that are verified using a slave BFM and test program.

Following this top-level discussion of how you verify a master and a slave component using the Mentor Verification IP Altera Edition is a brief example of how to run Qsys, the powerful system integration tool in Quartus® II software. This procedure shows you how to use Qsys to create a top-level DUT environment. For more details on this example refer to "Getting Started with Qsys and the BFMs" on page 629.

## Verifying a Slave DUT

A slave DUT component is connected to a master BFM at the signal-level. A master test program, written at the transaction-level, generates stimulus via the master BFM to verify the slave DUT. Figure 6-1 illustrates a typical top-level testbench environment.

**Figure 6-1. Slave DUT Top-level Testbench Environment**



In this example the master test program also compares the written data with that read back from the slave DUT, reporting the result of the comparison.

A top-level file instantiates and connects all the components required to test and monitor the DUT, and controls the system clock (*ACLK*) and reset (*ARESETn*) signals.

## AXI3 BFM Master Test Program

Using the AXI3 master BFM API, this Master Test Program creates a wide range of stimulus scenarios that test the slave DUT. This tutorial restricts the stimulus to a write transaction followed by a read transaction to the same address to compare the read data with the previously written data. For a complete code example of this Master Test Program, refer to SystemVerilog AXI3 Master BFM Test Program in Appendix A.

The code excerpt in Example 6-1 shows the Master Test Program defining a transaction variable *trans* of type *axi_transaction*, which holds the transaction record. A *timeout* transaction field is configured in the AXI3 Master BFM before waiting for the system reset to be completed. Before executing transactions, an additional system clock cycle is waited on after reset to satisfy the AXI3 protocol requirement specified in Section 11.1.2 of the AMBA AXI Protocol Specification.

**Example 6-1. Configuration and Initialization**

```
initial
begin
    axi_transaction trans;
    /******************
    ** Configuration **
    ******************/
    begin
      bfm.set_config(AXI_CONFIG_MAX_TRANSACTION_TIME_FACTOR, 1000);
    end

    /*******************
    ** Initialization **
    *******************/
    bfm.wait_on(AXI_RESET_POSEDGE);
    bfm.wait_on(AXI_CLOCK_POSEDGE);
```

To generate AXI3 protocol traffic, the Master Test Program must create the transaction before executing it. The code excerpt in Example 6-2 uses the AXI3 Master BFM *create_write_transaction ()* function, which provides only the start address argument of the transaction to be created. Because this function call provides only the start address, the burst-length argument automatically defaults to a value of zero—indicating a burst length of a single beat (refer to "Master BFM Configuration" on page 32 for more details). The created write transaction is then assigned to the transaction variable *trans*.

This example has an AXI3 data bus width of 32-bits; therefore a single beat of data conveys 4-bytes across the data bus. The *set_data_words()* function sets the *data_words[0]* transaction field with the value of 1 on byte lane 1, resulting in a value of 32'h0000_0100. However, the AXI3 protocol permits narrow transfers with the use of the write strobes signal *WSTRB* to indicate which byte lane contains valid write data, and therefore indicates to the slave DUT which data byte lane will be written into memory. Similarly, you can use the *set_write_strobes()* function to set the *write_strobes[0]* transaction field with the value of 4'b0010, indicating that only valid data is being transferred on byte lane 1. The write transaction *trans* then executes on the protocol signals using the *execute_transaction()* function.

All other transaction fields default to legal protocol values (refer to "Slave BFM Configuration" on page 66 for more details).

### Example 6-2. Write Transaction Creation and Execution

```
/************************
** Traffic generation: **
************************/
// 4 x Writes
// Write data value 1 on byte lanes 1 to address 1.
trans = bfm.create_write_transaction(1);
trans.set_data_words(32'h0000_0100, 0);
trans.set_write_strobes(4'b0010, 0);
$display ( "@ %t, master_test_program: Writing data (1) to address (1)",
$time);

// By default it will run in Blocking mode
bfm.execute_transaction(trans);
```

The code excerpt in Example 6-3 uses the AXI3 Master BFM to read the data that has just been written into the slave memory. The Master Test Program first creates a read transaction using the *create_read_transaction()* function and provides only the start address argument of the transaction to be created. Because this function call provides only the start address, the burst-length automatically defaults to a value of zero—indicating a burst length of a single beat (refer to "create_read_transaction()" on page 44 for more details). The created read transaction is then assigned to the transaction variable *trans*.

The *set_id()* function is then used to set the transaction *id* field to be 1 before executing the read transaction *trans* onto the protocol signals.

The read data is obtained using the *get_data_words(0)* function to get the *data_words[0]* transaction field value. The result of the read data is compared with the expected data—and a message displays the transcript.

**Example 6-3. Read Transaction Creation and Execution**

```
// Read data from address 1.
trans = bfm.create_read_transaction(1);
trans.set_size(AXI_BYTES_1);
trans.set_id(1);

bfm.execute_transaction(trans);
if (trans.get_data_words(0) == 32'h0000_0100)
   $display ( "@ %t, master_test_program: Read correct data (1) at
             address (1)", $time);
else
   $display ( "@ %t master_test_program: Error: Expected data (1) at
address 1, but got %d", $time, trans.get_data_words(0));
```

# AXI4 BFM Master Test Program

A master test program using the master BFM API is capable of creating a wide range of stimulus scenarios to verify a slave DUT. However, this tutorial restricts the master BFM stimulus to write transactions followed by read transactions to the same address, and then compares the read data with the previously written data. For a complete code listing of this master test program, refer to "SystemVerilog AXI4 Master BFM Test Program" on page 678.

The master test program contains:

- An initial block that creates and executes read and write transactions.
- Tasks *handle_write_resp_ready()* and *handle_read_data_ready()* to handle the delay of the write response channel *BREADY* signal and the read data channel *RREADY* signals, respectively.
- Variables *m_wr_resp_phase_ready_delay* and *m_rd_data_phase_ready_delay* to set the delay of the *BREADY and RREADY* signals
- A *master_ready_delay_mode* variable to configure the behavior of the handshake signals **VALID* to **READY* delay.

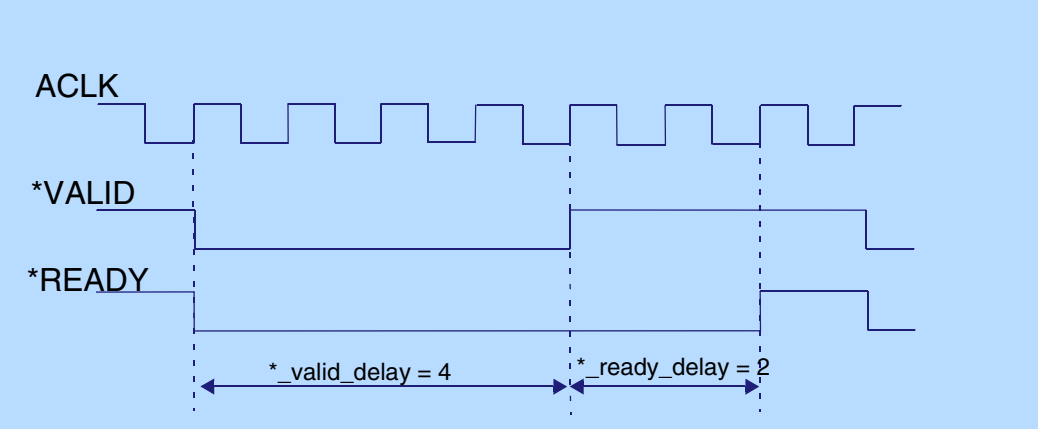
The following sections described the main tasks and variables:

## master_ready_delay_mode

The *master_ready_delay_mode* variable holds the configuration that defines the starting point of any delay applied to the *RREADY* and *BREADY* signals. It can be configured to the enumerated type values of *AXI4_VALID2READY* (default) or *AXI4_TRANS2READY*.

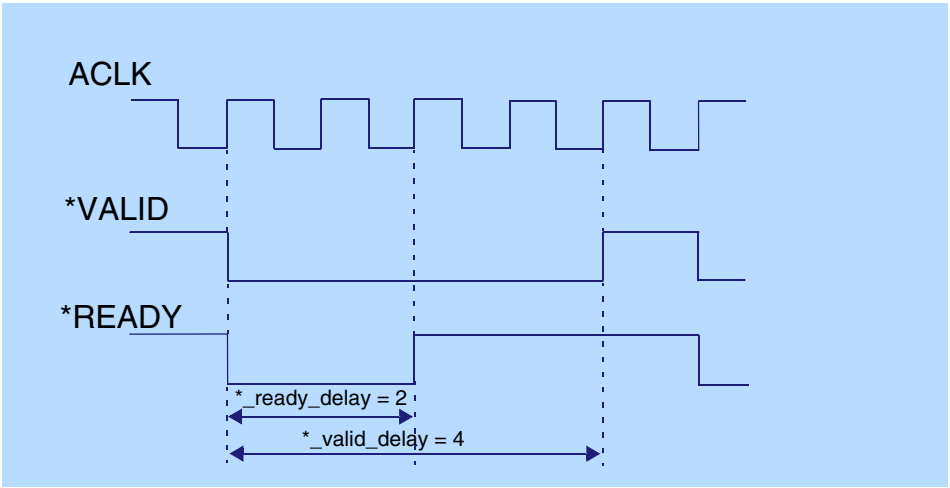
The default configuration (*master_ready_delay_mode = AXI4_VALID2READY*) corresponds to the delay measured from the positive edge of *ACLK* when **VALID* is asserted. Figure 6-2 shows how to achieve a **VALID* before **READY* handshake, respectively.

**Figure 6-2. master_ready_delay_mode = AXI4_VALID2READY**




The nondefault configuration (*slave_ready_delay_mode = AXI4_TRANS2READY*) corresponds to the delay measured from the completion of a previous transaction phase (**VALID* and **READY* both asserted). Figure 6-3 shows how to achieve a **READY* before **VALID* handshake.

**Figure 6-3. master_ready_delay_mode = AXI4_TRANS2READY**



Example 6-4 shows the configuration of the *master_ready_delay_mode* to its default value.

**Example 6-4. master_ready_delay_mode**

```
// Enum type for slave ready delay mode
// AXI4_VALID2READY - Ready delay for a phase will be applied from
//                start of phase (Means from when VALID is asserted).
// AXI4_TRANS2READY - Ready delay will be applied from the end of
//                previous phase. This might result in ready before valid.
typedef enum bit
{
   AXI4_VALID2READY = 1'b0,
   AXI4_TRANS2READY = 1'b1
} axi4_master_ready_delay_mode_e;

// Master ready delay mode selection : default it is VALID2READY
axi4_master_ready_delay_mode_e master_ready_delay_mode =
AXI4_VALID2READY;
```

## m_wr_resp_phase_ready_delay

The *m_wr_resp_phase_ready_delay* variable holds the *BREADY* signal delay. The delay value extends the length of the write response phase by a number of *ACLK* cycles. The starting point of the delay is determined by the *master_ready_delay_mode* variable configuration.

Example 6-5 shows the *AWREADY* signal delayed by 2 *ACLK* cycles. You can edit this variable to change the *AWREADY* signal delay.

**Example 6-5. m_wr_resp_phase_ready_delay**

```
// Variable : m_wr_resp_phase_ready_delay
int m_wr_resp_phase_ready_delay = 2;
```

## m_rd_data_phase_ready_delay

The *m_rd_data_phase_ready_delay* variable holds the *RREADY* signal delay. The delay value extends the length of each read data phase (beat) by a number of *ACLK* cycles. The starting point of the delay is determined by the *master_ready_delay_mode* variable configuration.

Example 6-6 shows the *RREADY* signal delayed by 2 *ACLK* cycles. You can edit this variable to change the *RREADY* signal delay.

**Example 6-6. m_rd_data_phase_ready_delay**

```
// Variable : m_rd_data_phase_ready_delay
int m_rd_data_phase_ready_delay = 2;
```

## initial block

In an *initial* block the master test program defines a transaction variable *trans* of type *axi4_transaction* to hold a record of a transaction during its lifetime, as shown in Example 6-7. The initial wait for the *ARESETn* signal to be deactivated, followed by a positive *ACLK* edge, satisfies the protocol requirement detailed in section A3.1.2 of the Protocol Specification.

**Example 6-7. Configuration and Initialization**

```
initial
begin
   axi4_transaction trans;


   /*******************
   ** Initialisation **
   *******************/
   bfm.wait_on(AXI4_RESET_POSEDGE);
   bfm.wait_on(AXI4_CLOCK_POSEDGE);
```

To generate protocol traffic, a master transaction must be created before executing it. The *create_write_transaction()* function creates a write transaction, passing in the start address of 1 as an argument to the function, as shown in Example 6-8. The burst-length argument automatically defaults to a value of zero—indicating a burst length of a single beat. The created write transaction is then assigned to the transaction variable *trans*.

This example has a write data bus width of 32-bits; therefore a single beat of data conveys 4-bytes across the data bus. The *trans.set_data_words()* function call loads the first element of the *data_words* transaction field with the value of 1 on byte lane 1, resulting in a value of *32'h0000_0100*.

The write strobes *WSTRB* signal indicates to the slave which byte lane contains valid write data to be written into the slave memory. The *trans.set_write_strobes()* function call loads the first element of the *write_strobes[0]* transaction field with the value of 4'b0010, indicating that only byte lane 1 contains valid data. All other transaction fields default to legal protocol values (refer to the *create_write_transaction()* function for more details).

Calling the *execute_transaction()* task executes the *trans* transaction onto the protocol signals.

### Example 6-8. Write Transaction Creation and Execution

```
/************************
** Traffic generation: **
************************/
// 4 x Writes
// Write data value 1 on byte lanes 1 to address 1.
trans = bfm.create_write_transaction(1);
trans.set_data_words(32'h0000_0100, 0);
trans.set_write_strobes(4'b0010, 0);
$display ( "@ %t, master_test_program: Writing data (1) to address (1)",
$time);

// By default it will run in Blocking mode
bfm.execute_transaction(trans);
```

The master test program creates a further three write transactions similar to that shown in Example 6-8, but with different start addresses and payload data.

The payload data previously written to the slave is read back and compared, reporting the outcome of the comparison. The *create_read_transaction()* function is used to create a read transaction, passing in the start address of 1 as an argument to the function, as shown in the following Example 6-9. The burst-length argument automatically defaults to a value of zero—indicating a burst length of a single beat. The created read transaction is then assigned to the transaction variable *trans*.

The *trans.set_size()* function call sets the transaction *size* field to a single byte and the *trans.set_id()* function call sets the transaction *id* field to be 1, before executing the read transaction *trans* on the protocol signals by calling the *execute_transaction()* task.

The read data is obtained using the *trans.get_data_words(0)* function to get the *data_words* transaction field value. The result of the read data is compared with the expected data—and a message displays the result.

### Example 6-9. Read Transaction Creation and Execution

```
// Read data from address 1.
trans = bfm.create_read_transaction(1);
trans.set_size(AXI_BYTES_1);
trans.set_id(1);

bfm.execute_transaction(trans);
if (trans.get_data_words(0) == 32'h0000_0100)
   $display ( "@ %t, master_test_program: Read correct data (1) at
            address (1)", $time);
else
   $display ( "@ %t master_test_program: Error: Expected data (1) at
address 1, but got %d", $time, trans.get_data_words(0));
```

The master test program creates three more read transactions similar to the transaction shown in Example 6-9, but with start addresses aligned to those previously used for the write transactions.

The code to create a write burst transaction that contains several data transfers (beats) is similar to that for a single transfer described previously. The master BFM *create_write_transaction()* function creates a write transaction, passing the start address and burst length as arguments to the function, as shown in Example 6-10.

**Note**

The burst length argument passed to the *create_write_transaction()* function is 1 less than the number of transfers (beats) in the burst. This aligns the burst length argument value with the value placed on the *AWLEN* protocol signals.

The *trans.set_write_data_mode()* function call sets the *write_data_mode* transaction field to start the write data burst simultaneously with the address phase of the transaction, before executing the *trans* transaction onto the protocol signals.

### Example 6-10. Write Burst Transaction Creation and Execution

```
// Write data burst length of 7 to start address 16.
    trans = bfm.create_write_transaction(16, 7);

    trans.set_size(AXI4_BYTES_4);
    trans.set_data_words('hACE0ACE1, 0);
    trans.set_data_words('hACE2ACE3, 1);
    trans.set_data_words('hACE4ACE5, 2);
    trans.set_data_words('hACE6ACE7, 3);
    trans.set_data_words('hACE8ACE9, 4);
    trans.set_data_words('hACEAACEB, 5);
    trans.set_data_words('hACECACED, 6);
    trans.set_data_words('hACEEACEF, 7);
    for(int i=0; i<8; i++)
        trans.set_write_strobes(4'b1111, i);
    trans.set_write_data_mode(AXI4_DATA_WITH_ADDRESS);
    $display ( "@ %t, master_test_program: Writing data burst of length 7
to start address 16", $time);

    bfm.execute_transaction(trans);
```

The master test program then creates another write burst transaction, similar to that explained in Example 6-10, but setting the byte lane zero write strobe to be invalid. Selected locations containing valid data in the slave memory are then read back and compared with the data previously written.

## handle_write_resp_ready()

The *handle_write_resp_ready()* task handles the *BREADY* signal for the write response channel. In a *forever* loop it delays the assertion of the *BREADY* signal based on the settings of the *master_ready_delay_mode* and *m_wr_resp_phase_ready_delay* as shown in Example 6-11.

If the *master_delay_ready_mode = AXI4_VALID2READY* then the *BREADY* signal is immediately deasserted using the nonblocking call to the *execute_write_resp_ready()* task and waits for a write channel response phase to occur with a call to the blocking *get_write_response_cycle()* task. A received write response phase indicates that the *BVALID* signal has been asserted, triggering the starting point for the delay of the *BREADY* signal by the number of *ACLK* cycles defined by *m_wr_resp_phase_ready_delay*. After the delay another call to the *execute_write_resp_ready()* task to assert the *BREADY* signal completes the *BREADY* handling. The *seen_valid_ready* flag is set to indicate the end of a response phase when both *BVALID* and *BREADY* are asserted, and the completion of the write transaction.

If the *master_delay_ready_mode = AXI4_TRANS2READY,* then a check of the *seen_valid_ready* flag is performed to indicate that a previous write transaction has completed. If a write transaction is still active (indicated by either *BVALID* or *BREADY* not asserted) then the code waits until the previous write transaction has completed. The *BREADY* signal is deasserted using the nonblocking call to the *execute_write_resp_ready()* task and waits for the number of *ACLK* cycles defined by *m_wr_resp_phase_ready_delay*. A nonblocking call to the *execute_write_resp_ready()* task to assert the *BREADY* signal completes the *BREADY* handling. The *seen_valid_ready* flag is cleared to indicate that only *BREADY* has been asserted.

## Example 6-11. handle_write_resp_ready()

```
// Task : handle_write_resp_ready
// This method assert/de-assert the write response channel ready signal.
// Assertion and de-assertion is done based on following variable's value:
// m_wr_resp_phase_ready_delay
// master_ready_delay_mode
task automatic handle_write_resp_ready;
   bit seen_valid_ready;

   int tmp_ready_delay;
   axi4_master_ready_delay_mode_e tmp_mode;

   forever
   begin
      wait(m_wr_resp_phase_ready_delay > 0);
      tmp_ready_delay = m_wr_resp_phase_ready_delay;
      tmp_mode        = master_ready_delay_mode;

      if (tmp_mode == AXI4_VALID2READY)
      begin
         fork
            bfm.execute_write_resp_ready(1'b0);
         join_none

         bfm.get_write_response_cycle;
         repeat(tmp_ready_delay - 1) bfm.wait_on(AXI4_CLOCK_POSEDGE);

         bfm.execute_write_resp_ready(1'b1);
         seen_valid_ready = 1'b1;
      end
      else  // AXI4_TRANS2READY
      begin
         if (seen_valid_ready == 1'b0)
         begin
            do
               bfm.wait_on(AXI4_CLOCK_POSEDGE);
            while (!((bfm.BVALID === 1'b1) && (bfm.BREADY === 1'b1)));
         end

         fork
            bfm.execute_write_resp_ready(1'b0);
         join_none

         repeat(tmp_ready_delay) bfm.wait_on(AXI4_CLOCK_POSEDGE);

         fork
            bfm.execute_write_resp_ready(1'b1);
         join_none
         seen_valid_ready = 1'b0;
      end
   end
endtask
```

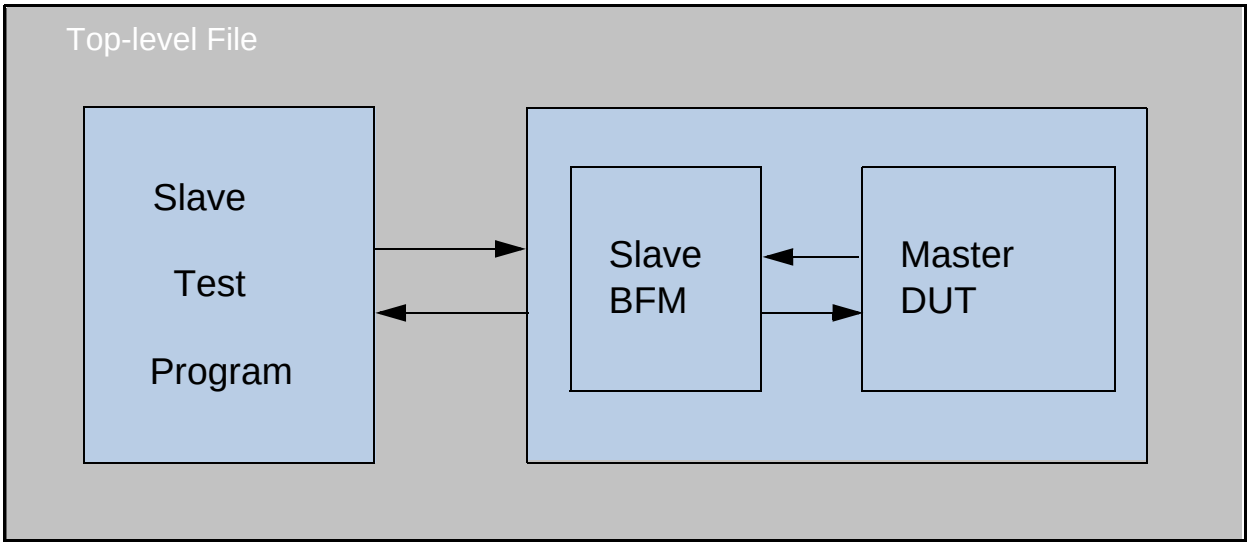
### handle_read_data_ready()

The *handle_read_data_ready()* task handles the *RREADY* signal for the read data channel. It delays the assertion of the *RREADY* signal based on the settings of the *master_ready_delay_mode* and *m_rd_data_phase_ready_delay*. The *handle_read_data_ready()* task code is similar in operation to the *handle_write_resp_ready()* task. Refer to the "SystemVerilog AXI4 Master BFM Test Program" on page 678 for the complete *handle_read_data_ready()* code listing.

# Verifying a Master DUT

A master DUT component is connected to a slave BFM at the signal-level. A slave test program, written at the transaction-level, generates stimulus via the slave BFM to verify the master DUT. Figure 6-4 illustrates a typical top-level testbench environment.

**Figure 6-4. Master DUT Top-level Testbench Environment**




In this example the slave test program is a simple memory model.

A top-level file instantiates and connects all the components required to test and monitor the DUT, and controls the system clock (*ACLK*) and reset (*ARESETn*) signals.

# AXI3 BFM Slave Test Program

The slave test program is a memory model and contains two APIs: a AXI3 Basic Slave API Definition and an Advanced AXI3 Slave API Definition.

The AXI3 Basic Slave API Definition allows you to create a wide range of stimulus scenarios to test a master DUT. This API definition simplifies the creation of slave stimulus based on the default response of *OKAY* to read and write transactions.

The Advanced AXI3 Slave API Definition allows you to create additional response scenarios to read and write transactions. For example, a successful exclusive transaction requires an *EXOKAY* response.

For a complete code listing of the slave test program, refer to "SystemVerilog AXI4 Slave BFM Test Program" on page 682.

## AXI3 Basic Slave API Definition

The Basic Slave Test Program API contains:

- Functions that read and write a byte of data to internal memory *do_byte_read()* and *do_byte_write()*, respectively.
- Functions to configure the AXI3 protocol channel handshake delays *set_read_address_ready_delay()*, *set_write_address_ready_delay()*, *set_write_data_ready_delay()*, *set_read_data_valid_delay()*, and *set_wr_resp_valid_delay()*.
- Tasks to process read and write transactions, *process_read* and *process_write*, respectively. If you need to create other responses, such as *EXOKAY*, *DECERR*, or *SLVERR*, then you will need to edit these tasks to provide the required response.
- A *slave_mode* transaction field controls the behavior of reading and writing to the internal memory.

The *internal memory* for the slave is defined as a sparse array of 8-bits, so that each byte of data is stored as an address/data pair.

### Example 6-12. internal memory

```
// Storage for a memory
bit [7:0] mem [*];
```

The *do_byte_read()* function, when called, will read a data byte from the internal memory, *mem,* given an address location as demonstrated in Example 6-13.

You can edit this function to modify the way the read data is extracted from the internal memory.

### Example 6-13. do_byte_read()

```
// Function : do_byte_read
// Function to provide read data byte from memory at
// particular input address
function bit[7:0] do_byte_read(addr_t addr);
   return mem[addr];
endfunction
```

The *do_byte_write()* function, when called, writes a data byte to the internal memory, *mem*, given an address location as Example 6-14 illustrates.

You can edit this function to modify the way the write data is stored in the internal memory.

### Example 6-14. do_byte_write()

```
// Function : do_byte_write
// Function to write data byte to memory at particular
// input address
function void do_byte_write(addr_t addr, bit [7:0] data);
   mem[addr] = data;
endfunction
```

The *set_read_address_ready_delay()* function, when called, configures the *ARREADY* handshake signal to be delayed by a number of *ACLK* cycles, which extends the length of the read address phase. The starting point of the delay is determined by the *delay_mode* operational transaction field (refer to "AXI3 BFM Delay Mode" on page 22 for details). Example 6-15 demonstrates setting the *ARREADY* signal delay by 4 *ACLK* cycles.

You can edit this function to change the *ARREADY* signal delay.

**Example 6-15. set_read_address_ready_delay()**

```
// Function : set_read_address_ready_delay
// This is used to set read address phase ready delay
// to extend phase
function void set_read_address_ready_delay(axi_transaction trans);
   trans.set_address_ready_delay(4);
endfunction
```

The *set_write_address_ready_delay()* function, when called, configures the *AWREADY* handshake signal to be delayed by a number of *ACLK* cycles, which extends the length of the write address phase. The starting point of the delay is determined by the *delay_mode* operational transaction field (refer to "AXI3 BFM Delay Mode" on page 22 for details). Example 6-16 demonstrates setting the *AWREADY* signal delay by 2 *ACLK* cycles.

You can edit this function to change the *AWREADY* signal delay.

**Example 6-16. set_write_address_ready_delay()**

```
// Function : set_write_address_ready_delay
// This is used to set write address phase ready delay
// to extend phase
function void set_write_address_ready_delay(axi_transaction trans);
  trans.set_address_ready_delay(2);
endfunction
```

The *set_write_data_ready_delay()* function, when called, configures the *WREADY* signal handshake to be delayed by a number of *ACLK* cycles, which extends the length of each write data phase (beat) in a write data burst. The starting point of the delay is determined by the configuration of the *delay_mode* operational transaction field (refer to "AXI3 BFM Delay Mode" on page 22 for details).

For each write data phase (beat), the delay value of the *WREADY* signal is stored in an element of the *data_ready_delay[]* array for the transaction, as demonstrated in Example 6-17.

You can edit this function to change the *WREADY* signal delay.

**Example 6-17. set_write_data_ready_delay()**

```
// Function : set_write_data_ready_delay
// This will set the ready delays for each write data phase
// in a write data burst
function void set_write_data_ready_delay(axi_transaction trans);
   for (int i = 0; i < trans.data_ready_delay.size(); i++)
      trans.set_data_ready_delay(i, i);
endfunction
```

The *set_read_data_valid_delay()* function, when called, configures the *RVALID* signal to be delayed by a number of *ACLK* cycles with the effect of delaying the start of each read data phase (beat) in a read data burst. The starting point of the delay is determined by the *delay_mode* operational transaction field (refer to "AXI3 BFM Delay Mode" on page 22 for details).

For each read data phase (beat), the delay value of the *RVALID* signal is stored in an element of the *data_valid_delay[]* array for the transaction, as demonstrated in Example 6-18.

You can edit this function to change the *RVALID* signal delay.

**Example 6-18. set_read_data_valid_delay()**

```
// Function : set_read_data_valid_delay
// This is used to set read response phase valid delays to start
// driving read data/response phases after specified delay.
function void set_read_data_valid_delay(axi_transaction trans);
  for (int i = 0; i < trans.data_valid_delay.size(); i++)
    trans.set_data_valid_delay(i, i);
endfunction
```

The *set_wr_resp_valid_delay()* function, when called, configures the *BREADY* signal handshake to be delayed by a number of *ACLK* cycles, which extends the length of the write response phase. The starting point of the delay is determined by the *delay_mode* operational transaction field (refer to "AXI3 BFM Delay Mode" on page 22 for details). Example 6-19 below demonstrates setting the *BREADY* signal delay by 2 *ACLK* cycles.

You can edit this function to change the *BREADY* signal delay.

**Example 6-19. set_wr_resp_valid_delay()**

```
// Function : set_wr_resp_valid_delay
// This is used to set write response phase valid delay to start
// driving write response phase after specified delay.
function void set_wr_resp_valid_delay(axi_transaction trans);
   trans.set_write_response_valid_delay(2);
endfunction
```

There is a *slave_mode* transaction field that you can configure to control the behavior of reading and writing to the internal memory. It has two modes *AXI_TRANSACTION_SLAVE* and *AXI_PHASE_SLAVE*.

**Example 6-20. slave_mode**

```
// Enum type for slave mode
// AXI_TRANSACTION_SLAVE - Works at burst level (write data is received at
//                         burst and read data/response is sent in burst)
// AXI_PHASE_SLAVE       - Write data and read data/response is serviced
//                         at phase level
   typedef enum bit
{
      AXI_TRANSACTION_SLAVE = 1'b0,
      AXI_PHASE_SLAVE       = 1'b1
} axi_slave_mode_e;


// Slave mode selection : Default is transaction-level slave
axi_slave_mode_e slave_mode = AXI_TRANSACTION_SLAVE;
```

The default *AXI_TRANSACTION_SLAVE* mode "saves up" an entire data burst and modifies the Slave Test Program internal memory in zero time for the whole burst. Therefore, a read from internal memory is buffered at the beginning of the read burst for the whole burst. The buffered read data is then transmitted over the protocol signals to the master on a phase-by-phase (beat-by-beat) basis. For a write, the write data burst is buffered on a phase-by-phase (beat-by-beat) basis for the whole burst. Only at the end of the write burst are the buffered contents written to the internal memory.

The *AXI_PHASE_SLAVE* mode changes the Slave Test Program internal memory on each data phase (beat). Therefore, a read from the internal memory occurs only when the read data phase (beat) actually starts on the protocol signals. For a write, data is written to the internal memory as soon as each individual write data phase (beat) completes.

**Note**

In addition to the above functions, you can configure other aspects of the AXI3 Slave BFM by using the functions: *"set_config()"* on page 72 and *"get_config()"* on page 74.

## Using the AXI3 Basic Slave Test Program API

As described in the AXI3 Basic Slave API Definition section, there are a set of tasks and functions that you can use to create stimulus scenarios based on a memory-model slave with a minimal amount of editing. However, consider the following configurations when using the Slave Test Program.

- *slave_mode* - The read and write channel interaction can cause simultaneous read and write transactions to occur at the same address. With the default *slave_mode* setting the read transaction data burst is buffered at the start of the burst and the write data burst is buffered at the end of the burst. This can result in the read data being stale at the time it is transmitted over the protocol signals. If this is an undesirable feature, then set the *Slave_mode* to be *AXI_PHASE_SLAVE*.
- *slave_ready_delay_mode* - By default the handshake **READY* signal will always follow, or be simultaneous with, the **VALID* signal. By configuring the *delay_mode* to be *AXI_TRANS2READY *READY* before **VALID* scenarios can be achieved.

## Advanced AXI3 Slave API Definition

**Note**

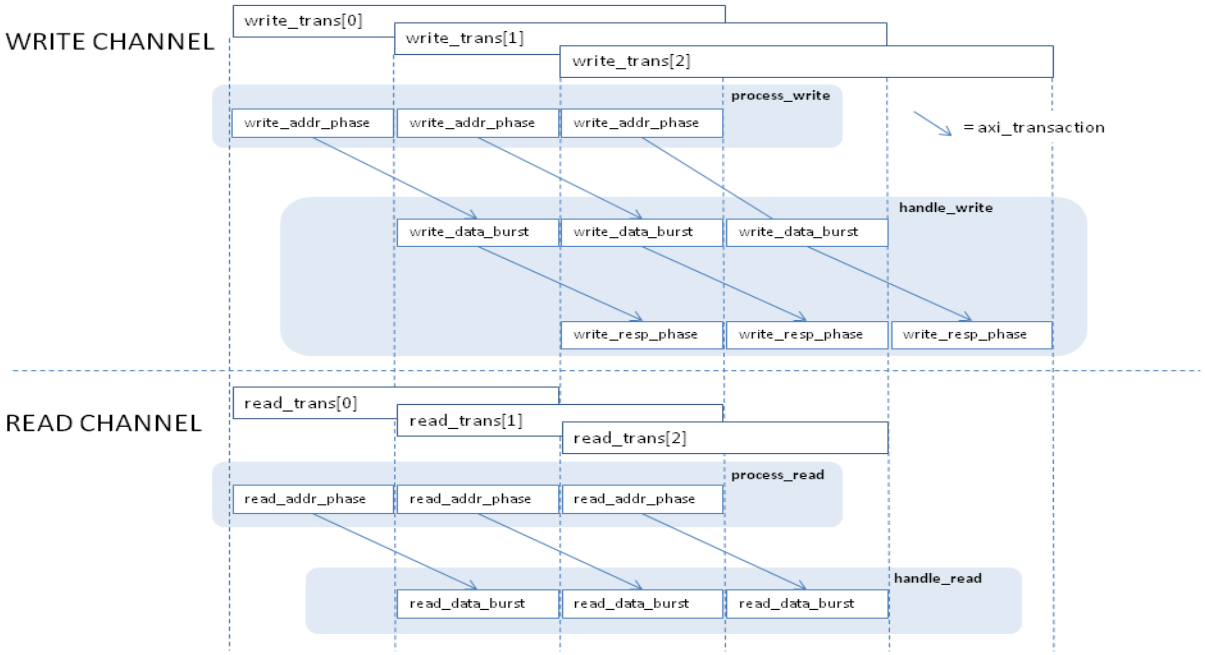
You are not required to edit the following Advance Slave API unless you require a different response than the default (*OKAY*) response.

The remaining section of this tutorial presents a walk-through of the Advanced Slave API in the slave test program. It consists of four main tasks, *process_read*, *process_write*, *handle_read* and *handle_write* in the slave test program, as shown in Figure 6-5.

The Advanced Slave API is capable of handling pipelined transactions. Pipelining can occur when a transaction starts before a previous transaction has completed. Therefore, a write transaction that starts before a previous write transaction has completed can be pipelined. Figure 6-5 shows the write channel having three concurrent *write_trans* transactions, whereby the *write_addr_phase[2]*, *write_data_burst[1]* and *write_response_phase[0]* are concurrently active on the write address, data and response channels, respectively.

Similarly, a read transaction that starts before a previous read transaction has completed can be pipelined. Figure 6-5 shows the read channel having two concurrent *read_trans* transactions, whereby the *read_addr_phase[1]* and *read_data_burst[0]* are concurrently active on the read address and data channels, respectively.

**Figure 6-5. Slave Test Program Advanced API Tasks**




In an initial block, the slave test program waits for the *ARESETn* signal to be deactivated and the following positive edge of *ACLK* before processing any read or write transactions simultaneously in a fork-join block, as demonstrated in Example 6-21.

**Example 6-21. Initialization and Transaction Processing**

```
initial
begin
   // Initialisation
   bfm.wait_on(AXI_RESET_POSEDGE);
   bfm.wait_on(AXI_CLOCK_POSEDGE);

  // Traffic generation
  fork
    process_read;
    process_write;
  join
end
```

The *process_read* task loops forever, processing read transactions as they occur from the master. It defines a local transaction variable *read_trans* of type *axi_transaction* to store a record of the read transaction while it is being processed. It then uses the Slave BFM function *create_slave_transaction()* to create a read transaction and assign it to the local *read_trans* record.

The *set_read_address_ready_delay()* function is called to configure the delay for the *ARREADY* signal before getting the read address phase using the Slave BFM *get_read_addr_phase()* task.

The subsequent *fork-join_none* block performs a nonblocking statement so that the *process_read* task can begin again to create another read transaction and get another read address phase before the current read transaction has completed. This permits concurrent read transactions to occur if the master issues a series of read address phases before any previous read transactions have completed.

In the *fork-join_none* block, the *read_trans* record is passed into the *handle_read()* function via the variable *t*.

**Example 6-22. process_read**

```
// Task : process_read
// This method keep receiving read address phase and calls another
// method to process received transaction.
task process_read;
  forever
  begin
    axi_transaction read_trans;

    read_trans = bfm.create_slave_transaction();
    set_read_address_ready_delay(read_trans);
    bfm.get_read_addr_phase(read_trans);

    fork
      begin
        automatic axi_transaction t = read_trans;
        handle_read(t);
      end
    join_none
    #0;
  end
endtask
```

The *set_read_data_ready()* function calls the *set_data_valid_delay()* function in the Slave BFM. It configures the delay for the assertion of *ARVALID* signal for each read data phase (beat) of a read burst.

**Example 6-23. set_read_data_ready()**

```
// Function : set_read_data_valid_delay
// This is used to set read response phase valid delays to start
// driving read data/response phases after specified delay.
function void set_read_data_valid_delay(axi_transaction trans);
  for (int i = 0; i < trans.data_valid_delay.size(); i++)
    trans.set_data_valid_delay(i, i);
endfunction
```

The *handle_read* task gets the data from the internal memory in either bursts or phases depending on the *slave_mode* configuration. It's *read_trans* argument contains the record of the read transaction up to the point of this task call, namely the content of the read address phase.

The call to *set_read_data_valid_delay()* configures the assertion of the *ARVALID* signal delay.

The task then loops for the number of addresses defined by calling the *get_read_addr()* helper function in the Slave BFM, assigning the local *mem_data* variable with read data by calling the *do_byte_read()* function.

The Slave BFM helper function *set_read_data()* then fills a complete read data bus width of data into the Slave BFM *data_words[]* array. At this point a read data phase is executed on to the read data channel if the *slave_mode* setting is *AXI_PHASE_SLAVE*, otherwise it executes a complete read data burst only when the Slave BFM *data_words[]* array contains a complete burst of read data.

**Example 6-24. handle_read**

```
// Task : handle_read
// This method reads data from memory and send read data/response
// either at burst or phase level depending upon slave working
// mode.
task automatic handle_read(input axi_transaction read_trans);
  addr_t addr[];
  bit [7:0] mem_data[];

  set_read_data_valid_delay(read_trans);

  for(int i = 0; bfm.get_read_addr(read_trans, i, addr); i++)
  begin
    mem_data = new[addr.size()];
    for (int j = 0; j < addr.size(); j++)
      mem_data[j] = do_byte_read(addr[j]);

    bfm.set_read_data(read_trans, i, addr, mem_data);

    if (slave_mode == AXI_PHASE_SLAVE)
      bfm.execute_read_data_phase(read_trans, i);
  end
    if (slave_mode == AXI_TRANSACTION_SLAVE)
      bfm.execute_read_data_burst(read_trans);
endtask
```

The processing of write transactions in the Slave Test Program works in a similar way as that described for read transactions. Processing a write transaction requires both a *process_write* task and a *handle_write* task.

The main difference is that the write transaction handling gets the write data burst and stores it in the Slave Test Program *internal memory* depending on the *slave_mode* setting, adhering to the state of the write strobes signal *WSTRB*. There is also an additional write response phase that is required for the AXI3 write channel.

### Example 6-25. process_write

```
// Task : process_write
// This method keep receiving write address phase and calls another
// method to process received transaction.
task process_write;
  forever
  begin
    axi_transaction write_trans;

    write_trans = bfm.create_slave_transaction();
    set_write_address_ready_delay(write_trans);
    bfm.get_write_addr_phase(write_trans);

    fork
      begin
        automatic axi_transaction t = write_trans;
        handle_write(t);
      end
    join_none
    #0;
  end
endtask
```

### Example 6-26. handle_write

```
// Task : handle_write
// This method receive write data burst or phases for write
// transaction depending upon slave working mode, write data to
// memory and then send response
task automatic handle_write(input axi_transaction write_trans);
  addr_t addr[];
  bit [7:0] data[];
  bit last;

  set_write_data_ready_delay(write_trans);

  if (slave_mode == AXI_TRANSACTION_SLAVE)
        begin
    bfm.get_write_data_burst(write_trans);

    for( int i = 0; bfm.get_write_addr_data(write_trans,
         i, addr, data); i++ )
    begin
      for (int j = 0; j < addr.size(); j++)
         do_byte_write(addr[j], data[j]);
    end
  end
  else
```

```
  begin
    for(int i = 0; (last == 1'b0); i++)
    begin
      bfm.get_write_data_phase(write_trans, i, last);

      void'(bfm.get_write_addr_data(write_trans, i, addr, data));
      for (int j = 0; j < addr.size(); j++)
        do_byte_write(addr[j], data[j]);
    end
  end

  set_wr_resp_valid_delay(write_trans);
  bfm.execute_write_response_phase(write_trans);
endtask
```

# AXI4 BFM Slave Test Program

The Slave Test Program is a memory model that contains two APIs: a AXI4 Basic Slave API Definition and an AXI4 Advanced Slave API Definition.

The AXI4 Basic Slave API Definition allows you to create a wide range of stimulus scenarios to test a master DUT. This API definition simplifies the creation of slave stimulus based on the default response of *OKAY* to master read and write transactions.

The AXI4 Advanced Slave API Definition allows you to create additional response scenarios to transactions. For example, a successful exclusive transaction requires an *EXOKAY* response.

For a complete code listing of the slave test program refer to "SystemVerilog AXI4 Slave BFM Test Program" on page 682.

## AXI4 Basic Slave API Definition

The Basic Slave Test Program API contains:

- Functions that read and write a byte of data to Internal Memory include *do_byte_read()* and *do_byte_write()*, respectively.
- Functions *set_read_data_valid_delay()* and *set_wr_resp_valid_delay()* to configure the delay of the read data channel *RVALID*, and write response channel *BVALID* signals, respectively.
- Variables *m_rd_addr_phase_ready_delay* and *m_wr_addr_phase_ready_delay* to configure the delay of the read/write address channel *ARVALID/AWVALID* signals, and *m_wr_data_phase_ready_delay* to configure the delay of the write response channel *BVALID* signal.
- A *slave_mode* variable to configure the behavior of reading and writing to the internal memory.

- A *slave_ready_delay_mode* variable to configure the behavior of the handshake signals **VALID* to **READY* delay.

## Internal Memory

The internal memory for the slave is defined as a sparse array of 8-bits, so that each byte of data is stored as an address/data pair.

**Example 6-27. internal memory**

```
// Storage for a memory
bit [7:0] mem [*];
```

## do_byte_read()

The *do_byte_read()* function, when called, will read a data byte from the Internal Memory *mem,* given an address location as shown below.

You can edit this function to modify the way the read data is extracted from the Internal Memory.

**Example 6-28. do_byte_read()**

```
// Function : do_byte_read
// Function to provide read data byte from memory at
// particular input address
function bit[7:0] do_byte_read(addr_t addr);
   return mem[addr];
endfunction
```

## do_byte_write()

The *do_byte_write()* function, when called, writes a data byte to the Internal Memory *mem*, given an address location as shown below.

You can edit this function to modify the way the write data is stored in the Internal Memory.

**Example 6-29. do_byte_write()**

```
// Function : do_byte_write
// Function to write data byte to memory at particular
// input address
function void do_byte_write(addr_t addr, bit [7:0] data);
   mem[addr] = data;
endfunction
```

## m_rd_addr_phase_ready_delay

The *m_rd_addr_phase_ready_delay* variable holds the *ARREADY* signal delay. The delay value extends the length of the read address phase by a number of *ACLK* cycles. The starting point of the delay is determined by the *slave_ready_delay_mode* variable configuration.

Example 6-30 shows the *ARREADY* signal delayed by 2 *ACLK* cycles. You can edit this variable to change the *ARREADY* signal delay.

**Example 6-30. m_rd_addr_phase_ready_delay**

```
// Variable : m_rd_addr_phase_ready_delay
int m_rd_addr_phase_ready_delay = 2;
```

## m_wr_addr_phase_ready_delay

The *m_wr_addr_phase_ready_delay* variable holds the *AWREADY* signal delay. The delay value extends the length of the write address phase by a number of *ACLK* cycles. The starting point of the delay is determined by the *slave_ready_delay_mode* variable configuration.

Example 6-31 shows the *AWREADY* signal delayed by 2 *ACLK* cycles. You can edit this variable to change the *AWREADY* signal delay.

**Example 6-31. m_wr_addr_phase_ready_delay**

```
// Variable : m_wr_addr_phase_ready_delay
int m_wr_addr_phase_ready_delay = 2;
```

## m_wr_data_phase_ready_delay

The *m_wr_data_phase_ready_delay* variable holds the *WREADY* signal delay. The delay value extends the length of each write data phase (beat) in a write data burst by a number of *ACLK* cycles. The starting point of the delay is determined by the *slave_ready_delay_mode* variable configuration.

Example 6-32 shows the *WREADY* signal delayed by 2 *ACLK* cycles. You can edit this function to change the *WREADY* signal delay.

**Example 6-32. m_wr_data_phase_ready_delay**

```
// Variable : m_wr_data_phase_ready_delay
int m_wr_data_phase_ready_delay = 2;
```

## set_read_data_valid_delay()

The *set_read_data_valid_delay()* function, when called, configures the *RVALID* signal to be delayed by a number of *ACLK* cycles with the effect of delaying the start of each read data phase (beat) in a read data burst. The delay value of the *RVALID* signal, for each read data phase, is stored in an array element of the *data_valid_delay* transaction field.

Example 6-33 shows the *RVALID* signal delay incrementing by an *ACLK* cycle between each read data phase for the length of the burst. You can edit this function to change the *RVALID* signal delay.

**Example 6-33. set_read_data_valid_delay()**

```
// Function : set_read_data_valid_delay
// This is used to set read response phase valid delays to start
// driving read data/response phases after specified delay.
function void set_read_data_valid_delay(axi4_transaction trans);
  for (int i = 0; i < trans.data_valid_delay.size(); i++)
    trans.set_data_valid_delay(i, i);
endfunction
```

## set_wr_resp_valid_delay()

The *set_wr_resp_valid_delay()* function, when called, configures the *BVALID* signal to be delayed by a number of *ACLK* cycles with the effect of delaying the start of the write response phase. The delay value of the *BVALID* signal is stored in the *write_response_valid_delay* transaction field.

Example 6-34 shows the *BVALID* signal delay set to 2 *ACLK* cycles. You can edit this function to change the *BVALID* signal delay.

**Example 6-34. set_wr_resp_valid_delay()**

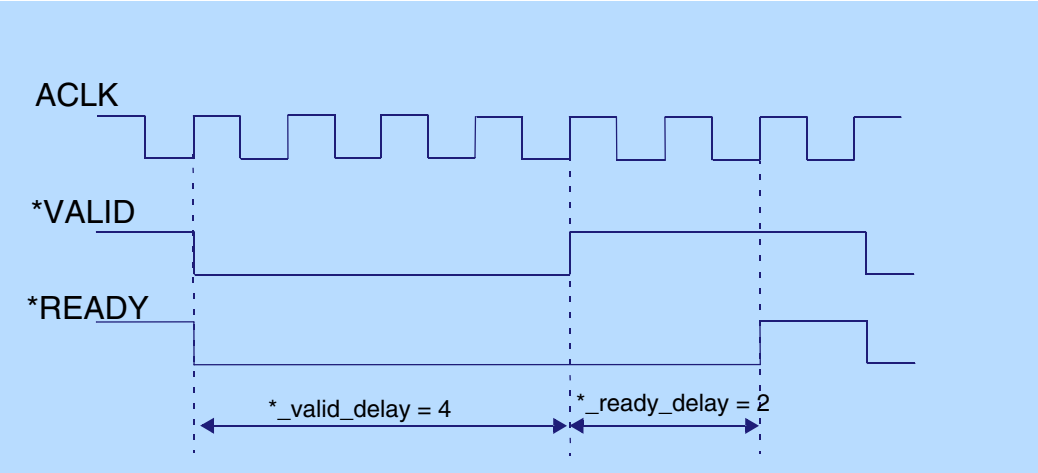
```
// Function : set_wr_resp_valid_delay
// This is used to set write response phase valid delay to start
// driving write response phase after specified delay.
function void set_wr_resp_valid_delay(axi4_transaction trans);
   trans.set_write_response_valid_delay(2);
endfunction
```

## slave_ready_delay_mode

The *slave_ready_delay_mode* variable holds the configuration that defines the starting point of any delay applied to the **READY* signals. It can be configured to the enumerated type values of *AXI4_VALID2READY* (default) or *AXI4_TRANS2READY*.

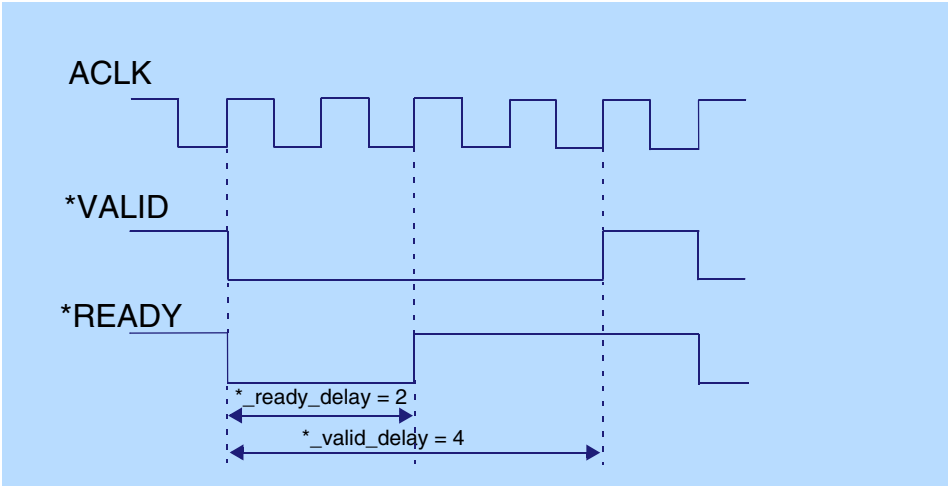
The default configuration (*slave_ready_delay_mode = AXI4_VALID2READY*) corresponds to the delay measured from the positive edge of *ACLK* when **VALID* is asserted. Figure 6-6 shows how to achieve a **VALID* before **READY* handshake.

**Figure 6-6. slave_ready_delay_mode = AXI4_VALID2READY**




The nondefault configuration (*slave_ready_delay_mode = AXI4_TRANS2READY*) corresponds to the delay measured from the completion of a previous transaction phase (**VALID* and **READY* both asserted). Figure 6-7 shows how to achieve a **READY* before **VALID* handshake.

**Figure 6-7. slave_ready_delay_mode = AXI4_TRANS2READY**



Example 6-35 shows the configuration of the *slave_ready_delay_mode* to its default value.

**Example 6-35. slave_ready_delay_mode**

```
// Enum type for slave ready delay mode
  // AXI4_VALID2READY - Ready delay for a phase will be applied from
  //                    start of phase (Means from when VALID is asserted).
  // AXI4_TRANS2READY - Ready delay will be applied from the end of
  //                     previous phase. This might result in ready before
valid.
  typedef enum bit
  {
    AXI4_VALID2READY = 1'b0,
    AXI4_TRANS2READY = 1'b1
  } axi4_slave_ready_delay_mode_e;

// Slave ready delay mode seclection : default it is AXI4_VALID2READY
axi4_slave_ready_delay_mode_e slave_ready_delay_mode = AXI4_VALID2READY;
```

## slave_mode

There is a *slave_mode* transaction field that you configure to control the behavior of reading and writing to Internal Memory. It has two modes *AXI4_TRANSACTION_SLAVE* and *AXI4_PHASE_SLAVE*.

**Example 6-36. slave_mode**

```
// Enum type for slave mode
// AXI4_TRANSACTION_SLAVE - Works at burst level (write data is received
// at burst and read data/response is sent in burst)
// AXI4_PHASE_SLAVE       - Write data and read data/response is serviced
//                          at phase level
   typedef enum bit
{
      AXI4_TRANSACTION_SLAVE = 1'b0,
      AXI4_PHASE_SLAVE       = 1'b1
} axi4_slave_mode_e;
// Slave mode selection : Default is transaction-level slave
axi4_slave_mode_e slave_mode = AXI4_TRANSACTION_SLAVE;
```

The default *AXI4_TRANSACTION_SLAVE* mode “saves up” an entire data burst and modifies the slave test program Internal Memory in zero time for the whole burst. Therefore, a burst read from Internal Memory is buffered from the beginning of the burst to the end of the burst. The buffered read burst data is then transmitted over the protocol signals to the master on a phase-by-phase (beat-by-beat) basis. For a write, the data burst received over the protocol signals is buffered from the beginning of the burst to the end of the burst. At the end of the write burst, the buffered contents are written to the Internal Memory.

The *AXI4_PHASE_SLAVE* mode updates the slave test program Internal Memory on each data phase (beat). Therefore, a read from the Internal Memory occurs only when the read data phase (beat) actually starts to be transmitted on the protocol signals. For a write, data is written to the Internal Memory as soon as each write data phase (beat) is received on the protocol signals.

**Note**

In addition to the above variables and procedures, you can configure other aspects of the AXI4 Slave BFM by using the procedures: *"set_config()"* on page 72 and *"get_config()"* on page 74.

## Using the AXI4 Basic Slave Test Program API

There are a set of tasks and functions that you can use to create stimulus scenarios based on a memory-model slave with a minimal amount of editing, as described in the AXI4 Basic Slave API Definition section.

Consider the following configurations when using the slave test program.

- *slave_mode* - The read and write channel interaction can cause simultaneous read and write transactions to occur at the same address. With the default *slave_mode* setting the read transaction data burst is buffered at the start of the burst and the write data burst is buffered at the end of the burst. This can result in the read data being stale at the time it is transmitted over the protocol signals. If this is an undesirable feature, then set the *slave_mode* to be *AXI4_PHASE_SLAVE*.
- *slave_ready_delay_mode* - By default each channel handshake **READY* signal will always follow, or be simultaneous with, the channel **VALID* signal. By configuring the *slave_ready_delay_mode* to be *AXI4_TRANS2READY*, **READY* before **VALID* scenarios can be achieved.

## AXI4 Advanced Slave API Definition

**Note**

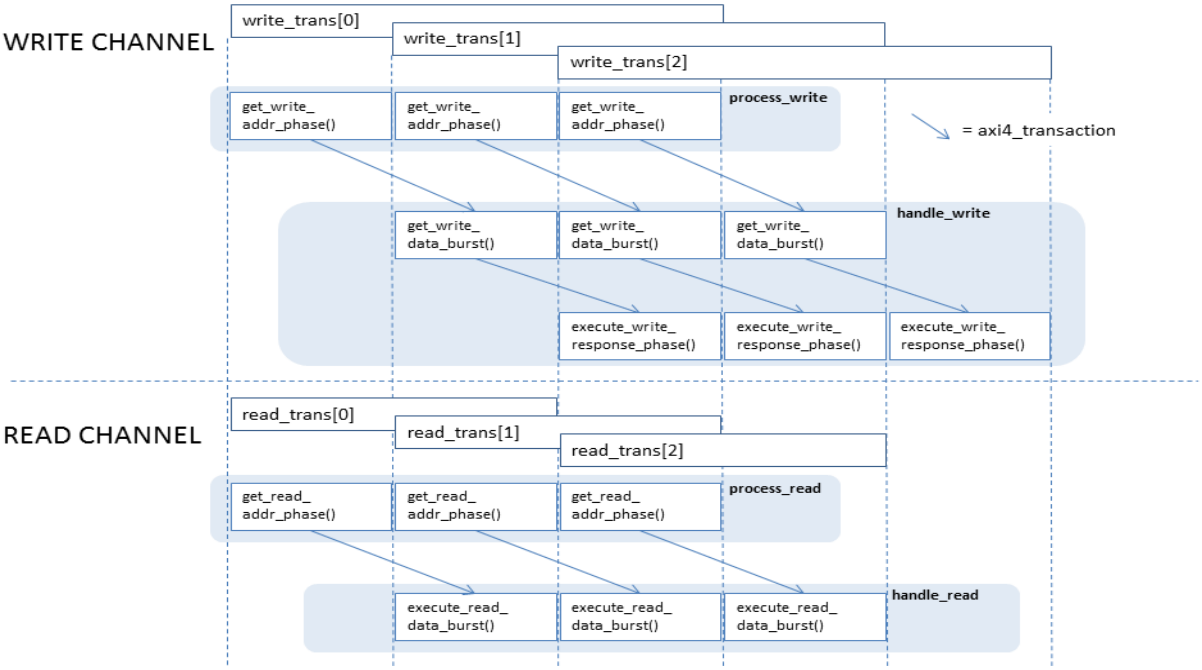
You are not required to edit the following Advance Slave API unless you require a different response than the default (*OKAY*) response.

The remaining section of this tutorial presents a walk-through of the Advanced Slave API in the slave test program. It consists of four main tasks, *process_read()*, *process_write()*, *handle_read()*, and *handle_write()* in the slave test program, as shown in Figure 6-8. There are additional *handle_write_addr_ready()*, *handle_read_addr_ready()* and *handle_write_data_ready()* tasks to handle the handshake *AWREADY*, *ARREADY* and *WREADY* signals, respectively.

The Advanced Slave API is capable of handling pipelined transactions. Pipelining can occur when a transaction starts before a previous transaction has completed. Therefore, a write transaction that starts before a previous write transaction has completed can be pipelined. Figure 6-8 shows the write channel having three concurrent *write_trans* transactions, whereby the *get_write_addr_phase[2]*, *get_write_data_burst[1]* and *execute_write_response_phase[0]* are concurrently active on the write address, data and response channels, respectively.

Similarly, a read transaction that starts before a previous read transaction has completed can be pipelined. Figure 6-8 shows the read channel having two concurrent *read_trans* transactions, whereby the *get_read_addr_phase[1]* and *execute_read_data_burst[0]* are concurrently active on the read address and data channels, respectively.

**Figure 6-8. Slave Test Program Advanced API Tasks**




## initial block

In an *initial* block, the slave test program waits for the *ARESETn* signal to be deactivated, followed by a positive *ACLK* edge, before simultaneously calling tasks to process read and write transactions, and handle the channel **READY* signals in a fork-join block, as shown in Example 6-37 below.

**Example 6-37. Initialization and Transaction Processing**

```
initial
begin
   // Initialisation
   bfm.wait_on(AXI4_RESET_POSEDGE);
   bfm.wait_on(AXI4_CLOCK_POSEDGE);
```

```
// Traffic generation
    fork
      process_read;
      process_write;
      handle_write_addr_ready;
      handle_read_addr_ready;
      handle_write_data_ready;
    join
end
```

## process_read()

The *process_read()* task loops forever, processing read transactions as they occur from the master. A local transaction variable *read_trans* of type *axi4_transaction* is defined to hold a record of the read transaction while it is being processed. A slave transaction is created by calling the *create_slave_transaction()* function and assigned to the *read_trans* record.

The subsequent *fork-join_none* block performs a nonblocking statement so that the *process_read()* task can begin again to create another read transaction record and get another read address phase before the current read transaction has completed. This permits concurrent read transactions to occur if the master issues a series of read address phases before any previous read transactions have completed.

In the *fork-join_none* block, the *read_trans* record is passed into the *handle_read()()* function via the variable *t*.

**Example 6-38. process_read()**

```
// Task : process_read
// This method keep receiving read address phase and calls another
// method to process received transaction.
task process_read;
  forever
  begin
    axi4_transaction read_trans;

    read_trans = bfm.create_slave_transaction();
    bfm.get_read_addr_phase(read_trans);

    fork
      begin
        automatic axi4_transaction t = read_trans;
        handle_read(t);
      end
    join_none
    #0;
  end
endtask
```

## handle_read()

The *handle_read()* task gets the data from the Internal Memory as a burst or a phase (beat), depending on the *slave_mode* configuration. The *read_trans* argument contains the record of the read transaction up to the point of this task call, namely the content of the read address phase.

The call to *set_read_data_valid_delay()* configures the *RVALID* signal delay for each phase (beat).

In a *loop* the call to the *get_read_addr()* helper function returns the actual address addr for a particular byte location. This byte address is used to read the data byte from Internal Memory with the call to the *do_byte_read()* function, assigning the local *mem_data* variable with read data *do_byte_read()*. The call to the *set_read_data()* helper function sets the byte with in the read transaction record. The loop continues reading and setting the read data from internal memory for the whole of the read data phase (beat).

If the *slave_mode* configuration is set to the default of *AXI4_TRANSACTION_SLAVE* then the loop continues until the read data has been set for the whole burst. Otherwise the individual read data phase is executed over the protocol signals by calling the *execute_read_data_phase()*.

After the for loop is complete, *execute_read_data_burst()* is called for the default configuration of *slave_mode* and the read burst is executed over the protocol signals.

**Example 6-39. handle_read**

```
// Task : handle_read
// This method reads data from memory and send read data/response
// either at burst or phase level depending upon slave working
// mode.
task automatic handle_read(input axi4_transaction read_trans);
   addr_t addr[];
   bit [7:0] mem_data[];

   set_read_data_valid_delay(read_trans);

   for(int i = 0; bfm.get_read_addr(read_trans, i, addr); i++)
   begin
      mem_data = new[addr.size()];
      for (int j = 0; j < addr.size(); j++)
         mem_data[j] = do_byte_read(addr[j]);

      bfm.set_read_data(read_trans, i, addr, mem_data);

      if (slave_mode == AXI4_PHASE_SLAVE)
         bfm.execute_read_data_phase(read_trans, i);
   end
   if (slave_mode == AXI4_TRANSACTION_SLAVE)
      bfm.execute_read_data_burst(read_trans);
endtask
```

## process_write()

The processing of write transactions in the slave test program works in a similar way as that previously described for the *process_read()* task.

**Example 6-40. process_write**

```
// Task : process_write
// This method keep receiving write address phase and calls another
// method to process received transaction.
task process_write;
  forever
  begin
    axi4_transaction write_trans;

    write_trans = bfm.create_slave_transaction();
    bfm.get_write_addr_phase(write_trans);

    fork
      begin
        automatic axi4_transaction t = write_trans;
        handle_write(t);
      end
    join_none
    #0;
  end
endtask
```

## handle_write()

The *handle_write()* task works in a similar way as that previously described for the *handle_read()* task. The main difference is that the write transaction handling gets the write data burst and stores it in the slave test program Internal Memory depending on the *slave_mode* setting, and adhering to the state of the *WSTRB* write strobes signal. There is an additional write response phase that is required for the write response channel, as shown in Example 6-41below.

**Example 6-41. handle_write()**

```
// Task : handle_write
// This method receive write data burst or phases for write
// transaction depending upon slave working mode, write data to
// memory and then send response
task automatic handle_write(input axi4_transaction write_trans);
   addr_t addr[];
   bit [7:0] data[];
   bit last;

   if (slave_mode == AXI4_TRANSACTION_SLAVE)
   begin
      bfm.get_write_data_burst(write_trans);

      for( int i = 0; bfm.get_write_addr_data(write_trans,
            i, addr, data); i++ )
      begin
         for (int j = 0; j < addr.size(); j++)
            do_byte_write(addr[j], data[j]);
      end
   end
   else
   begin
      for(int i = 0; (last == 1'b0); i++)
      begin
         bfm.get_write_data_phase(write_trans, i, last);
         void'(bfm.get_write_addr_data(write_trans, i, addr, data));
         for (int j = 0; j < addr.size(); j++)
            do_byte_write(addr[j], data[j]);
      end
   end
   set_wr_resp_valid_delay(write_trans);
   bfm.execute_write_response_phase(write_trans);
endtask
```

## handle_write_addr_ready()

The *handle_write_addr_ready()* task handles the *AWREADY* signal for the write address channel. In a forever loop it delays the assertion of the *AWREADY* signal based on the settings of the *slave_ready_delay_mode* and *m_wr_addr_phase_ready_delay* as shown in Example 6-42 below.

If the *slave_delay_ready_mode = AXI4_VALID2READY* then the *AWREADY* signal is deasserted using the nonblocking call to the *execute_write_data_ready()* task and waits for a write channel address phase to occur with a call to the blocking *get_write_addr_cycle()* task. A received write address phase indicates that the *AWVALID* signal has been asserted, triggering the starting point for the delay of the *AWREADY* signal by the number of *ACLK* cycles defined by *m_wr_addr_phase_ready_delay*. Another call to the *execute_write_addr_ready()* task to assert the *AWREADY* signal completes the *AWREADY* handling. The *seen_valid_ready* flag is set to indicate the end of a address phase when both *AWVALID* and *AWREADY* are asserted.

If the *slave_delay_ready_mode = AXI4_TRANS2READY* then a check of the *seen_valid_ready* flag is performed to indicate that a previous write address phase has completed. If a write address phase is still active (indicated by either *AWVALID* or *AWREADY* not asserted) then the code waits until the previous write address phase has completed. The *AWREADY* signal is then deasserted using the nonblocking call to the *execute_write_addr_ready()* task and waits for the number of *ACLK* cycles defined by *m_wr_addr_phase_ready_delay*. A nonblocking call to the *execute_write_addr_ready()* task to assert the *AWREADY* signal completes the *AWREADY* handling. The *seen_valid_ready* flag is cleared to indicate that only *AWREADY* has been asserted.

**Example 6-42. handle_write_addr_ready()**

```
// Task : handle_write_addr_ready
// This method assert/de-assert the write address channel ready signal.
// Assertion and de-assertion is done based on m_wr_addr_phase_ready_delay
task automatic handle_write_addr_ready;
   bit seen_valid_ready;

   int tmp_ready_delay;
   axi4_slave_ready_delay_mode_e tmp_mode;

   forever
   begin
      wait(m_wr_addr_phase_ready_delay > 0);
      tmp_ready_delay = m_wr_addr_phase_ready_delay;
      tmp_mode        = slave_ready_delay_mode;

      if (tmp_mode == AXI4_VALID2READY)
      begin
         fork
            bfm.execute_write_addr_ready(1'b0);
         join_none

         bfm.get_write_addr_cycle;
         repeat(tmp_ready_delay - 1) bfm.wait_on(AXI4_CLOCK_POSEDGE);
```

```
            bfm.execute_write_addr_ready(1'b1);
            seen_valid_ready = 1'b1;
         end
         else  // AXI4_TRANS2READY
         begin
            if (seen_valid_ready == 1'b0)
            begin
               do
                  bfm.wait_on(AXI4_CLOCK_POSEDGE);
               while (!((bfm.AWVALID === 1'b1) && (bfm.AWREADY === 1'b1)));
            end

            fork
               bfm.execute_write_addr_ready(1'b0);
            join_none

            repeat(tmp_ready_delay) bfm.wait_on(AXI4_CLOCK_POSEDGE);

            fork
               bfm.execute_write_addr_ready(1'b1);
            join_none
            seen_valid_ready = 1'b0;
         end
      end
   endtask
```

## handle_read_addr_ready()

The *handle_read_addr_ready()* task handles the *ARREADY* signal for the read address channel. In a forever loop, it delays the assertion of the *ARREADY* signal based on the settings of the *slave_ready_delay_mode* and *m_rd_addr_phase_ready_delay*. The *handle_read_addr_ready()* task code is similar in operation to the *handle_write_addr_ready()* task. Refer to the "SystemVerilog AXI4 Slave BFM Test Program" on page 682 for the complete *handle_read_addr_ready()* code listing.

## handle_write_data_ready()

The *handle_write_data_ready()* task handles the *WREADY* signal for the write data channel. In a forever loop it delays the assertion of the *WREADY* signal based on the settings of the *slave_ready_delay_mode* and *m_wr_data_phase_ready_delay*. The *handle_write_data_ready()* task code is similar in operation to the *handle_write_addr_ready()* task. Refer to the "SystemVerilog AXI4 Slave BFM Test Program" on page 682 for the complete *handle_write_data_ready()* code listing.

# Chapter 7
# VHDL API Overview

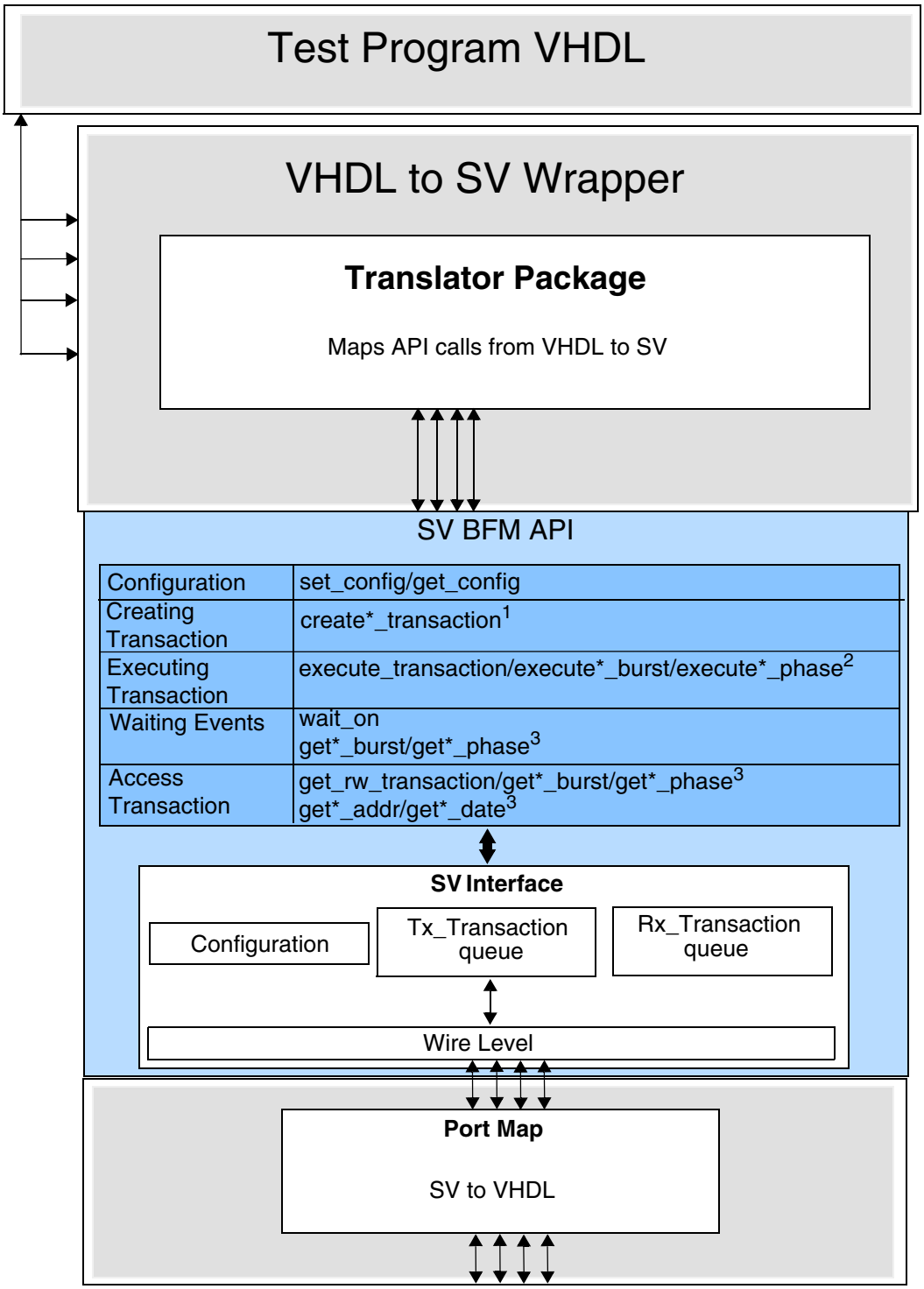
This section describes the VHDL Application Programming Interface (API) procedures for all the BFM (master, slave, and monitor) components. For each BFM, you can configure protocol transaction fields that execute on the protocol signals and control the operational transaction fields that permit delays between the handshake signals for each of the five address, data, and response channels.

In addition, each BFM API has procedures that wait for certain events to occur on the system clock and reset signals, and procedures to get and set information about a particular transaction.

**Note**

The VHDL API is built on the SystemVerilog API. An internal VHDL to SystemVerilog (SV) wrapper casts the VHDL BFM API procedure calls to the SystemVerilog BFM API tasks and functions.

**Figure 7-1. VHDL BFM Internal Structure**




**Notes:** 1. Refer to the create*_transaction()
2. Refer to the execute_transaction(), execute*_burst(), execute*_phase()
3. Refer to the get*()

# Configuration

Configuration sets timeout delays, error reporting, and other attributes of the BFM.

Each BFM has a *set_config()* procedure that sets the configuration of the BFM. Refer to the individual BFM API for valid details.

Each BFM has a *get_config()* procedure that returns the configuration of the BFM. Refer to the individual BFM API for details.

## set_config()

For example, the following test program code sets the burst timeout factor for a transaction in the master BFM:

```
-- Setting the burst timeout factor to 1000
set_config(AXI_CONFIG_BURST_TIMEOUT_FACTOR, 1000, bfm_index,
      axi_tr_if_0(bfm_index))
```

In the above example, the *bfm_index* specifies the BFM.

**Note**

The above test program code segment is for AXI3 BFMs. Substitute the *AXI_CONFIG_BURST_TIMEOUT_FACTOR* enumeration with *AXI4_CONFIG_BURST_TIMEOUT_FACTOR*, and the *axi_tr_if_0* path name with *axi4_tr_if_0* for AXI4 BFMs.

## get_config()

For example, the following test program code gets the protocol signal hold time in the master BFM:

```
-- Getting the burst timeout factor
get_config(AXI_CONFIG_HOLD_TIME, config_value, bfm_index,
      axi_tr_if_0(bfm_index))
```

In the above example, the *bfm_index* specifies the BFM.

**Note**

The above test program code segment is for AXI3 BFMs. Substitute the *AXI_CONFIG_HOLD_TIME* enumeration with *AXI4_CONFIG_HOLD_TIME*, and the *axi_tr_if_0* path name with *axi4_tr_if_0* for AXI4 BFMs.

# Creating Transactions

To transfer information between a master BFM and slave DUT over the protocol signals a transaction must be created in the master test program. Similarly, to transfer information between a master DUT and a slave BFM a transaction must be created in the slave test program. To monitor the transfer of information using a monitor BFM, a transaction is created in the monitor test program.

Creating a transaction also creates a Transaction Record that exists for the life of the transaction. This transaction record can be accessed by the BFM test program during the life of the transaction as it transfers information between the master and slave.

## Transaction Record

The transaction record contains transaction fields. There are two main types of transaction fields, *protocol* and *operational*.

Protocol fields hold transaction information that is transferred over the protocol signals. For example, the *prot* field is transferred over the *AWPROT* protocol signals during a write transaction.

Operational fields hold information about how and when the transaction is transferred. Their content is not transferred over protocol signals. For example, the *operation_mode* field controls the blocking/nonblocking operation of the transaction, but is not transferred over the protocol signals.

## AXI3 Transaction Definition

The transaction record exists as a SystemVerilog class definition in each BFM. Example 7-1 below shows the definition of the *axi_transaction* class members that form the transaction record.

**Example 7-1. AXI3 Transaction Definition**

```
// Global Transaction Class
class axi_transaction;
    // Protocol
    bit [((`MAX_AXI_ADDRESS_WIDTH) - 1):0]  addr;
    axi_size_e size;
    axi_burst_e burst;
    axi_lock_e lock;
    axi_cache_e cache;
    axi_prot_e prot;
    bit [((`MAX_AXI_ID_WIDTH) - 1):0]  id;
    bit [3:0] burst_length;
    bit [(((`MAX_AXI_RDATA_WIDTH > `MAX_AXI_WDATA_WIDTH) ?
`MAX_AXI_RDATA_WIDTH : `MAX_AXI_WDATA_WIDTH)) - 1):0] data_words [];
    bit [(((`MAX_AXI_WDATA_WIDTH / 8)) - 1):0] write_strobes [];
    axi_response_e resp[];
    bit [7:0] addr_user;
    axi_rw_e read_or_write;
    int address_valid_delay;
    int data_valid_delay[];
    int write_response_valid_delay;
    int address_ready_delay;
    int data_ready_delay[];
    int write_response_ready_delay;

    // Housekeeping
    bit gen_write_strobes = 1'b1;
    axi_operation_mode_e  operation_mode  = AXI_TRANSACTION_BLOCKING;
    axi_delay_mode_e      delay_mode      = AXI_VALID2READY;
    axi_write_data_mode_e write_data_mode = AXI_DATA_AFTER_ADDRESS;
    bit data_beat_done[];
    bit transaction_done;

...

endclass
```

**Note**

The *axi_transaction* class code above is shown for information only. Access to each transaction record during its lifetime is performed via the various *set*()* and *get*()* procedures detailed later in this Chapter.

## AXI4 Transaction Definition

The transaction record exists as a SystemVerilog class definition in each BFM. Example 7-2 below shows the definition of the *axi4_transaction* class members that form the transaction record.

**Example 7-2. AXI4 Transaction Definition**

```
// Global Transaction Class
class axi4_transaction;
    // Protocol
    axi4_rw_e read_or_write;
    bit [((`MAX_AXI4_ADDRESS_WIDTH) - 1):0]  addr;
    axi4_prot_e prot;
    bit [3:0] region;
    axi4_size_e size;
    axi4_burst_e burst;
    axi4_lock_e lock;
    axi4_cache_e cache;
    bit [3:0] qos;
    bit [((`MAX_AXI4_ID_WIDTH) - 1):0]  id;
    bit [7:0] burst_length;
    bit [((`MAX_AXI4_USER_WIDTH) - 1):0]  addr_user;
    bit [(((`MAX_AXI4_RDATA_WIDTH > `MAX_AXI4_WDATA_WIDTH) ?
`MAX_AXI4_RDATA_WIDTH : `MAX_AXI4_WDATA_WIDTH)) - 1):0] data_words [];
    bit [(((`MAX_AXI4_WDATA_WIDTH / 8)) - 1):0] write_strobes [];
    axi4_response_e resp[];
    int address_valid_delay;
    int data_valid_delay[];
    int write_response_valid_delay;
    int address_ready_delay;
    int data_ready_delay[];
    int write_response_ready_delay;

    // Housekeeping
    bit gen_write_strobes = 1'b1;
    axi4_operation_mode_e  operation_mode  = AXI4_TRANSACTION_BLOCKING;
    axi4_write_data_mode_e write_data_mode = AXI4_DATA_AFTER_ADDRESS;
    bit data_beat_done[];
    bit transaction_done;

...

endclass
```

**Note**

The *axi4_transaction* class code above is shown for information only. Access to each transaction record during its lifetime is performed via the various *set*()* and *get*()* procedures detailed later in this Chapter.

Table 7-1 describes the transaction fields in the transaction record.

**Table 7-1. Transaction Fields**

| Transaction Field | Description |
|---|---|
| **Protocol Transaction Fields** | |
| addr | A bit vector (of length equal to the *ARADDR/AWADDR* signal bus width) to hold the start *address* of the first transfer (beat) of a transaction. The *addr* value is transferred over the *ARADDR* or *AWADDR* signals for a read or write transaction, respectively. |
| prot | An enumeration to hold the *protection* type of a transaction. The types of *protection* are:<br>**_NORM_SEC_DATA (default)<br>**_PRIV_SEC_DATA<br>**_NORM_NONSEC_DATA<br>**_PRIV_NONSEC_DATA<br>**_NORM_SEC_INST<br>**_PRIV_SEC_INST<br>**_NORM_NONSEC_INST<br>**_PRIV_NONSEC_INST<br>The *prot* value is transferred over the *ARPROT* or *AWPROT* signals for a read or write transaction, respectively. |
| region | (AXI4) A 4-bit vector to hold the *region* identifier of a transaction. The *region* value is transferred over the *ARREGION* or *AWREGION* signals for a read or write transaction, respectively. |
| size | An enumeration to hold the *size* of a transaction. The types of *size* are:<br>**_BYTES_1<br>**_BYTES_2<br>**_BYTES_4<br>**_BYTES_8<br>**_BYTES_16<br>**_BYTES_32<br>**_BYTES_64<br>**_BYTES_128<br>The *size* value is transferred over the *ARSIZE* or *AWSIZE* signals for a read or write transaction, respectively. |
| burst | An enumeration to hold the *burst* of a transaction. The types of *burst* are:<br>**_FIXED<br>**_INCR<br>**_WRAP<br>**_BURST_RSVD<br>The *burst* value is transferred over the *ARBURST* or *AWBURST* signals for a read or write transaction, respectively. |

| Transaction Field | Description |
|---|---|
| **Protocol Transaction Fields** | |
| lock | An enumeration to hold the *lock* of a transaction. The types of *lock* are:<br><br>**_NORMAL<br>**_EXCLUSIVE<br>(AXI3) AXI_LOCKED<br>(AXI3) AXI_LOCKED_RSVD<br><br>The *lock* value is transferred over the *ARLOCK* or *AWLOCK* signals for a read or write transaction, respectively. |
| cache | (AXI3) An enumeration to hold the *cache* of a transaction. The types of *cache* are:<br><br>AXI_NONCACHE_NONBUF; (default)<br>AXI_BUF_ONLY;<br>AXI_CACHE_NOALLOC;<br>AXI_CACHE_BUF_NOALLOC;<br>AXI_CACHE_RSVD0;<br>AXI_CACHE_RSVD1;<br>AXI_CACHE_WTHROUGH_ALLOC_R_ONLY;<br>AXI_CACHE_WBACK_ALLOC_R_ONLY;<br>AXI_CACHE_RSVD2;<br>AXI_CACHE_RSVD3;<br>AXI_CACHE_WTHROUGH_ALLOC_W_ONLY;<br>AXI_CACHE_WBACK_ALLOC_W_ONLY;<br>AXI_CACHE_RSVD4;<br>AXI_CACHE_RSVD5;<br>AXI_CACHE_WTHROUGH_ALLOC_RW;<br>AXI_CACHE_WBACK_ALLOC_RW;<br><br>The *cache* value is transferred over the *ARCACHE* or *AWCACHE* signals for a read or write transaction, respectively.<br><br>(AXI4) An enumeration to hold the *cache* of a transaction. The types of *cache* are:<br><br>AXI4_NONMODIFIABLE_NONBUF<br>AXI4_BUF_ONLY<br>AXI4_CACHE_NOALLOC<br>AXI4_CACHE_2<br>AXI4_CACHE_3<br>AXI4_CACHE_RSVD4<br>AXI4_CACHE_RSVD5<br>AXI4_CACHE_6<br>AXI4_CACHE_7<br>AXI4_CACHE_RSVD8<br>AXI4_CACHE_RSVD9<br>AXI4_CACHE_10<br>AXI4_CACHE_11<br>AXI4_CACHE_RSVD12<br>AXI4_CACHE_RSVD13<br>AXI4_CACHE_14<br>AXI4_CACHE_15<br><br>The *cache* value is transferred over the *ARCACHE* or *AWCACHE* signals for a read or write transaction, respectively. |

| Transaction Field | Description |
|---|---|
| **Protocol Transaction Fields** | |
| qos | (AXI4) A 4-bit vector to hold the *Quality of Service* identifier of a transaction. The *qos* value is transferred over the *ARQOS* or *AWQOS* signals for a read or write transaction, respectively. |
| id | A bit vector (of length equal to the *ARID/AWID* signal bus width) to hold the *identification tag* of a transaction. The *id* value is transferred over the *AWID/BID* signals for a write transaction and over the ARID/RID signals for a read transaction. |
| burst_length | A 4-bit (8-bit for AXI4) vector to hold the burst length of a transaction. The *burst_length* value is transferred over the *ARLEN* or *AWLEN* signals for a read or write transaction, respectively. |
| addr_user | A bit vector (of length equal to the *ARUSER/AWUSER* signal bus width) to hold the address channel *user data* of a transaction. The *addr_data* value is transferred over the *ARUSER* or *AWUSER* signals for a read or write transaction, respectively. |
| data_words | An unsized array of bit vectors (of length equal to the greater of the *RDATA/WDATA* signal bus widths) to hold the *data words* of the payload. A *data_words* array element is transferred over the RDATA or WDATA signals per beat of the read or write data channel, respectively. |
| write_strobes | An unsized array of bit vectors (of length equal to the WDATA signal bus width divided by 8) to hold the write strobes. A *write_strobes* array element is transferred over the WSTRB signals per beat of the write data channel. |
| resp | An unsized enumeration array to hold the *responses* of a transaction. The types of *response* are:<br><br>**_OKAY;<br>**_EXOKAY;<br>**_SLVERR;<br>**_DECERR;<br><br>A *resp* array element value is transferred over the *RRESP* signals per beat of the read data channel, and over the *BRESP* signals for a write transaction, respectively. |
| **Operational Transaction Fields** | |
| read_or_write | An enumeration to hold the *read or write* control flag. The types of *read_or_write* are:<br><br>**_TRANS_READ<br>**_TRANS_WRITE |
| address_valid_delay | An integer to hold the delay value of the address channel *AWVALID and ARVALID* signals (measured in *ACLK* cycles) for a read or write transaction, respectively. |
| data_valid_delay | An unsized array of integers to hold the delay values of the data channel *WVALID and RVALID* signals (measured in *ACLK* cycles) for a read or write transaction, respectively. |

| Transaction Field | Description |
|---|---|
| write_response_valid_delay | An integer to hold the delay value of the write response channel *BVALID* signal (measured in *ACLK* cycles) for a write transaction. |
| address_ready_delay | An integer to hold the delay value of the address channel *AWREADY and ARREADY* signals (measured in *ACLK* cycles) for a read or write transaction, respectively. |
| data_ready_delay | An unsized array of integers to hold the delay values of the data channel *WREADY and RREADY* signals (measured in *ACLK* cycles) for a read or write transaction, respectively. |
| write_response_ready_delay | An integer to hold the delay value of the write response channel *BREADY* signal (measured in *ACLK* cycles) for a write transaction. |
| gen_write_strobes | Automatically correct write strobes flag. Refer to Automatic Correction of Byte Lane Strobes for details. |
| operation_mode | An enumeration to hold the *operation mode* of the transaction. The two types of *operation_mode* are:<br><br>**_TRANSACTION_NON_BLOCKING<br>**_TRANSACTION_BLOCKING |
| delay_mode | (AXI3) An enumeration to hold the *delay mode* control flag. The types of *delay_mode* are:<br><br>AXI_VALID2READY<br>AXI_TRANS2READY<br><br>Refer to AXI3 BFM Delay Mode for details. |
| write_data_mode | (AXI3) An enumeration to hold the *write data mode* control flag. The types of *write_data_mode* are:<br><br>**_DATA_AFTER_ADDRESS<br>**_DATA_WITH_ADDRESS |
| data_beat_done | An unsized bit array to hold the *done* flag for each beat in a read or write data burst when it has completed. |
| transaction_done | A bit to hold the *done* flag for a transaction when it has completed. |

The master BFM API allows you to create a master transaction by providing only the address and burst length arguments for a read, or write, transaction. All other protocol transaction fields automatically default to legal protocol values to create a complete master transaction record. Refer to the *create_read_transaction()* and *create_write_transaction()* procedures for default protocol read and write transaction field values.

The slave BFM API allows you to create a slave transaction by providing no arguments. All protocol transaction fields automatically default to legal protocol values to create a complete slave transaction record. Refer to the *create_slave_transaction()* procedure for default protocol transaction field values.

The monitor BFM API allows you to create a slave transaction by providing no arguments. All protocol transaction fields automatically default to legal protocol values to create a complete

slave transaction record. Refer to the *create_monitor_transaction()* procedure for default protocol transaction field values.

**Note**

If you change a protocol transaction field value from its default, it is then valid for all future transactions until a new value is set.

## create*_transaction()

There are two master BFM API procedures available to create transactions, *create_read_transaction()* and *create_write_transaction()*, a *create_slave_transaction()* slave BFM API procedure, and a *create_monitor_transaction()* monitor BFM API procedure.

For example, to create a simple write transaction with a start address of 1, and a single data phase with a data value of 2, the master BFM test program would contain the following code:

```
-- * = axi| axi4
-- ** = AXI | AXI4
-- Define local variables to hold the transaction ID
-- and data word.
variable tr_id: integer;
variable data_words :  std_logic_vector(**_MAX_BIT_SIZE-1 downto 0);

-- Create a master write transaction and set data_word value
create_write_transaction(1, tr_id, bfm_index, *_tr_if_0(bfm_index));
data_words(31 downto 0) := x"00000200";
set_data_words(data_words, tr_id, bfm_index, *_tr_if_0(bfm_index));
```

For example, to create a simple slave transaction the slave BFM test program would contain the following code:

```
-- Define a local variable write_trans to hold the transaction ID
variable write_trans : integer;

-- Create a slave transaction

create_slave_transaction(write_trans, bfm_index, *_tr_if_0(bfm_index));
```

In the above examples, the *bfm_index* specifies the BFM.

# Executing Transactions

Executing a transaction in a master/slave BFM test program initiates the transaction onto the protocol signals. Each master/slave BFM API has execution tasks that push transactions into the BFM internal transaction queues. Figure 7-1 on page 168 illustrates the internal BFM structure.

## execute_transaction(), execute*_burst(), execute*_phase()

If the DUT is a slave then the *execute_transaction()* procedure is called in the master BFM test program. If the DUT is a master then the *execute*_burst()* and *execute*_phase()* procedures are called in the slave BFM test program.

For example, to execute a master write transaction the master BFM test program would contain the following code:

```
-- * = axi| axi4
-- By default the execution of a transaction will block
execute_transaction(tr_id, bfm_index, *_tr_if_2(bfm_index));
```

For example, to execute a slave write response phase, the slave BFM test program would contain the following code:

```
-- * = axi| axi4
-- By default the execution of a phase will block
execute_write_response_phase(write_trans, bfm_index,
*_tr_if_2(bfm_index));
```

In the above example, the *bfm_index* specifies the BFM.

# Waiting Events

Each BFM API has procedures that block the test program code execution until an event has occurred.

The *wait_on()* procedure blocks the test program until an *ACLK* or *ARESETn* signal event has occurred before proceeding.

The get*_transaction(), get*_burst(), get*_phase(), get*_cycle() procedures block the test program code execution until a complete transaction, burst, phase or cycle has occurred, respectively.

## wait_on()

For example, a BFM test program can wait for the positive edge of the *ARESETn* signal using the following code:

```
-- * = axi| axi4
-- ** = AXI | AXI4
-- Block test program execution until the positive edge of the clock
wait_on(**_RESET_POSEDGE, bfm_index, *_tr_if_0(bfm_index));
```

In the above example, the *bfm_index* specifies the BFM.

## get*_transaction(), get*_burst(), get*_phase(), get*_cycle()

For example, a slave BFM test program can use a received write address phase to form the response of the write transaction. The test program gets the write address phase for the transaction by calling the *get_write_addr_phase()* procedure. This task blocks until it has received the address phase, allowing the test program to then call the *execute_write_response_phase()* procedure for the transaction, as shown in the slave BFM test program in Example 7-3 below.

**Example 7-3. Slave BFM Test Program Using get_write_addr_phase()**

```
-- * = axi| axi4
-- ** = AXI | AXI4
create_slave_transaction(write_trans, bfm_index, *_tr_if_0(bfm_index));
get_write_addr_phase(write_trans, bfm_index, *_tr_if_0(bfm_index));

...

execute_write_response_phase(write_trans, bfm_index, **_PATH_2,
*_tr_if_2(bfm_index));
```

In the above example, the *bfm_index* specifies the BFM.

**Note**

Not all BFM APIs support the full complement of *get*_transaction(), get*_burst(), get*_phase(), get*_cycle()* tasks. Refer to the individual master, slave or monitor BFM API for details.

# Access Transaction Record

Each BFM API has procedures that can access a complete, or partially complete, Transaction Record. The *set*()* and *get*()* procedures are used in a test program to set and get information from the transaction record.

## set*()

For example, to set the *WSTRB* write strobes signal for the first phase (beat) in the Transaction Record of a write transaction, the master test program would use the *set_write_strobes()* procedure, as shown in the code below.

```
-- * = axi| axi4
set_write_strobes(2, tr_id, bfm_index, *_tr_if_0(bfm_index));
```

In the above example, the *bfm_index* specifies the BFM.

## get*()

For example, a slave BFM test program uses a received write address phase to get the *AWPROT* signal value from the Transaction Record, as shown in the slave BFM test program code below.

```
-- * = axi| axi4
-- Wait for a write address phase;
get_write_addr_phase(slave_trans, bfm_index, *axi_tr_if_0(bfm_index));

...

-- Get the AWPROT signal value of the slave transaction
get_prot(prot_value, slave_trans, bfm_index, *axi_tr_if_0(bfm_index));
```

In the above example, the *bfm_index* specifies the BFM.

# Operational Transaction Fields

Operational transaction fields control the way in which a transaction is executed on the protocol signals. They also provide an indicator of when a data phase (beat) or transaction is complete.

## Automatic Correction of Byte Lane Strobes

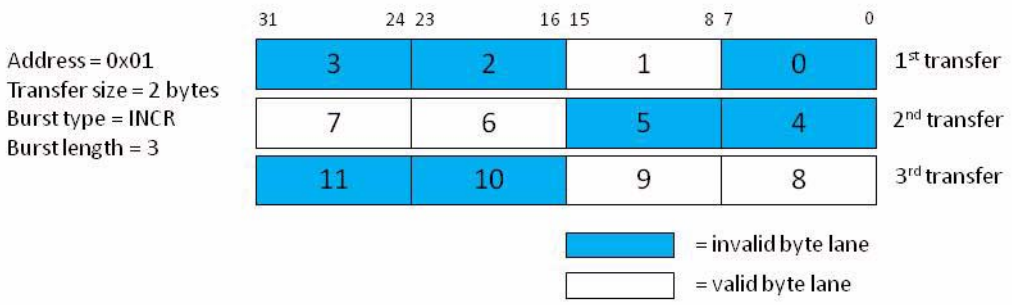
The master BFM permits unaligned and narrow write transfers by using byte lane strobe (*WSTRB)* signals to indicate which byte lanes contain valid data per data phase (beat).

When you create a write transaction in your master BFM test program, the *write_strobes* variable is available to store the write strobe values for each write data phase (beat) in the transaction. To assist you in creating the correct byte lane strobes automatic correction of any previously set *write_strobes* is performed by default during execution of the write transaction, or write data phase (beat). You can disable this default behavior by setting the transaction field *gen_write_strobes = 0*, which allows any previously set *write_strobes* to pass through uncorrected onto the protocol *WSTRB* signals. In this mode, with the automatic correction disabled, you are responsible for setting the correct *write_strobes* for the whole transaction.

The automatic correction algorithm performs a bit-wise AND operation on any previously set *write_strobes*. To do the corrections, the automatic correction algorithm uses the equations described in the AMBA AXI Protocol Specification, version 2.0, section A3.4.1, that define valid write data byte lanes for legal protocol. Therefore, if you require automatic generation of all *write_strobes*, before the write transaction executes, you must set all *write_strobes* to 1, indicating that all bytes lanes initially contain valid write data, prior to execution of the write transaction. Automatic correction will then set the relevant *write_strobes* to 0 to produce legal protocol *WSTRB* signals.

For example, Figure Figure 7-2 below demonstrates byte lanes that can contain valid data for a write transaction that has a start address = 0x01, size = 0b001 (2 bytes), type = INCR and length = 0b0010 (3 beats), for a 32-bit write data bus.

**Figure 7-2. Valid Data on Byte Lanes During a Write Transaction**




In the above example, if you set all *write_strobes[]* array elements to 1 prior to executing the write transaction, automatic correction produces the following results during execution of the transaction.

| | Prior to Execution | | During Execution |
|---|---|---|---|
| 1st data phase | write_strobes[0]=0b1111 | -> | write_strobes[0]=0b0010 |
| 2nd data phase | write_strobes[1]=0b1111 | -> | write_strobes[1]=0b1100 |
| 3rd data phase | write_strobes[2]=0b1111 | -> | write_strobes[2]=0b0011 |

If you randomly set all *write_strobes[]* array elements to 0 or 1, prior to executing the write transaction, automatic correction **only** corrects those *write_strobes[]* array elements that were previously set to 1, as shown below.

| | Prior to Execution | | During Execution |
|---|---|---|---|
| 1st data phase | write_strobes[0]=0b1010 | -> | write_strobes[0]=0b0010 |
| 2nd data phase | write_strobes[1]=0b1010 | -> | write_strobes[1]=0b1000 |
| 3rd data phase | write_strobes[2]=0b1010 | -> | write_strobes[2]=0b0010 |

**Note**

To automatically generate all *WSTRB* signals for a write transaction, set all *write_strobes[]* array elements to 1 prior to execution of the write transaction or write data burst.

# Operation Mode

By default, each read or write transaction performs a blocking operation which prevents a following transaction from starting until the current active transaction completes.

You can configure this behavior to be nonblocking by setting the *operation_mode* transaction field to the enumerate type value ***_TRANSACTION_NON_BLOCKING* instead of the default ***_TRANSACTION_BLOCKING*.

For example, in a master BFM test program you create a transaction by calling the *create_read_transaction()* or *create_write_transaction()* tasks which creates a transaction record. Before executing the transaction record the *operation_mode* can be changed as follows:

```
-- * = axi| axi4
-- ** = AXI | AXI4
-- Create a write transaction to create a transaction record
create_write_transaction(1, tr_id, bfm_index, *_tr_if_0(bfm_index));

-- Change operation_mode to be nonblocking in the transaction record
set_operation_mode(**_TRANSACTION_NON_BLOCKING, tr_id, bfm_index,
                   *_tr_if_0(bfm_index));
```

In the above example, the *bfm_index* specifies the BFM.

# Channel Handshake Delay

Each of the five protocol channels have **VALID* and **READY* handshake signals to control the rate at which information is transferred between a master and slave. The API to control these handshake signals differs between the AXI3 BFMs and AXI4 BFMs. Refer to the AXI3 BFM Handshake Delay and AXI3 BFM Delay Mode for details of the AXI3 BFM API, and AXI4 BFM Handshake Delay for details of the AXI4 BFM API.

## AXI3 BFM Handshake Delay

The delay between the **VALID* and **READY* handshake signals for each of the five protocol channels can be configured. The delay can be defined per phase (beat) basis for a particular transaction, measured from the positive edge of *ACLK* when **VALID* is asserted. The delay can also be set from the completion of a previous transaction phase (**VALID* and **READY* both asserted).

## AXI3 BFM Handshake Signal Delay Transaction Fields

There are transaction fields to configure the desired handshake delay pattern for a particular transaction phase on any of the five protocol channels. The master BFM configures the **VALID* and **READY* signal delays that it asserts, and the slave BFM configures the **VALID* and **READY* signal delays that it asserts. Table 7-2 below specifies which operational delay transaction fields are configured by the master and slave BFMs.

**Table 7-2. Handshake Signal Delay Transaction Fields**

| Signal | Operational Transaction Field | Configuration BFM |
|---|---|---|
| AWVALID | address_valid_delay | Master |
| AWREADY | address_ready_delay | Slave |
| WVALID | data_valid_delay | Master |
| WREADY | data_ready_delay | Slave |
| BVALID | write_response_valid_delay | Slave |
| BREADY | write_response_ready_delay | Master |
| ARVALID | address_valid_delay | Master |
| ARREADY | address_ready_delay | Slave |
| RVALID | data_valid_delay | Slave |
| RREADY | data_ready_delay | Master |

**Note**

The data channel handshake signal transaction fields (*data_valid_delay[]* and *data_ready_delay[]*) are defined as arrays so that the **VALID* to **READY* delay can be configured on a per data phase (beat) basis in a transaction.

## AXI4 BFM Handshake Delay

The delay between the **VALID* and **READY* handshake signals for each of the five protocol channels is controlled in a BFM test program using *execute_*_ready()*, *get_*_ready()* and *get_*_cycle()* tasks. The *execute_*_ready()* tasks place a value onto the **READY* signals and the *get_*_ready()* tasks retrieve a value from the **READY* signals. The *get_*_cycle()* tasks wait for a **VALID* signal to be asserted and are used to insert a delay between the **VALID* and **READY* signals in the BFM test program.

For example, the master BFM test program code below inserts a specified delay between the read channel *RVALID* and *RREADY* handshake signals using the *execute_read_data_ready()* and *get_read_data_cycle()* tasks.

```
-- Set the RREADY signal to '0'.
execute_read_data_ready(0, 1, bfm_index, AXI4_PATH_6,
                           axi4_tr_if_6(bfm_index));

-- Wait for the RVALID signal to be asserted.
get_read_data_cycle(bfm_index, AXI4_PATH_6,
                       axi4_tr_if_6(bfm_index));

-- Add delay between RVALID and RREADY.
for i in  0 to 2 loop
   wait_on(AXI4_CLOCK_POSEDGE, bfm_index, AXI4_PATH_6,
            axi4_tr_if_6(bfm_index));
end loop;
execute_read_data_ready(1, 1, bfm_index, AXI4_PATH_6,
                           axi4_tr_if_6(bfm_index));
```

In the above example, the *bfm_index* specifies the BFM.

## AXI4 BFM **VALID* Signal Delay Transaction Fields

The transaction record contains a **_valid_delay* transaction field for each of the five protocol channels to configure the delay value prior to the assertion of the **VALID* signal for the channel. The master BFM holds the delay configuration for the **VALID* signals that it asserts, and the slave BFM holds the delay configuration for the **VALID* signals that it asserts. The Table 7-3 below specifies which **_valid_delay* fields are configured by the master and slave BFMs.

**Table 7-3. Master and Slave *valid_delay Configuration Fields**

| Signal | Operational Transaction Field | Configuration BFM |
|---|---|---|
| AWVALID | address_valid_delay | Master |
| WVALID | data_valid_delay | Master |
| BVALID | write_response_valid_delay | Slave |
| ARVALID | address_valid_delay | Master |
| RVALID | data_valid_delay | Slave |

**Note**

In the transaction record the data channel handshake signal transaction field (*data_valid_delay[]*) is defined as and array so that the **VALID* delay can be configured on a per data phase (beat) basis in a transaction.

## AXI4 BFM **READY* Handshake Signal Delay Transaction Fields

The transaction record contains a **_ready_delay* transaction field for each of the five protocol channels to store the delay value between the assertion of the **VALID* and **READY* handshake signals for the channel. The table below specifies the **_ready_delay* field corresponding to the **READY* signal delay.

**Table 7-4. Master and Slave *_ready_delay Fields**

| Signal | Operational Transaction Field |
|---|---|
| AWREADY | address_ready_delay |
| WREADY | data_ready_delay |
| BREADY | write_response_ready_delay |
| ARREADY | address_ready_delay |
| RREADY | data_ready_delay |

**Note**

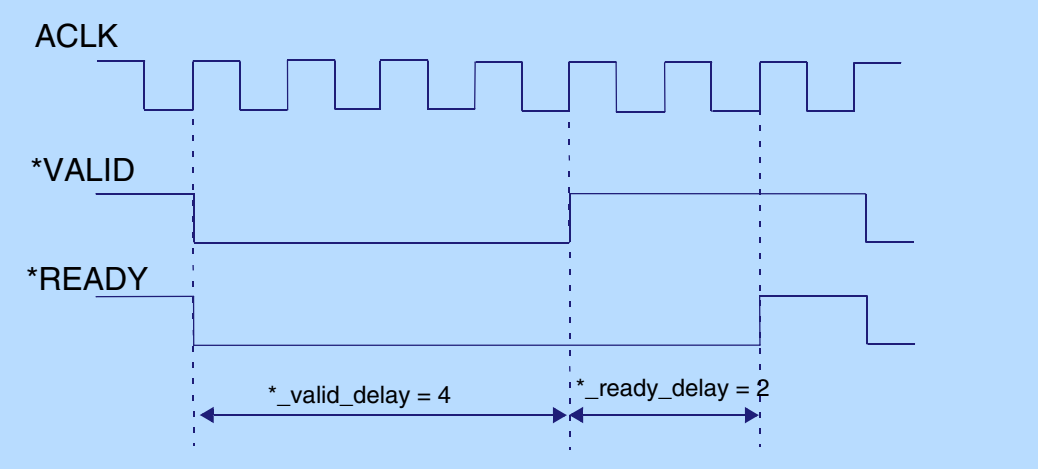
In the transaction record the data channel handshake signal transaction field (*data_ready_delay[]*) is defined as an array so that the **READY* delay can be recorded on a per data phase (beat) basis in a transaction.

# AXI3 BFM Delay Mode

The delay mode can be configured on a per transaction basis via the *delay_mode* operational transaction field. This transaction field can be configured to the enumerated type values of *AXI_VALID2READY* (default) or *AXI_TRANS2READY*.

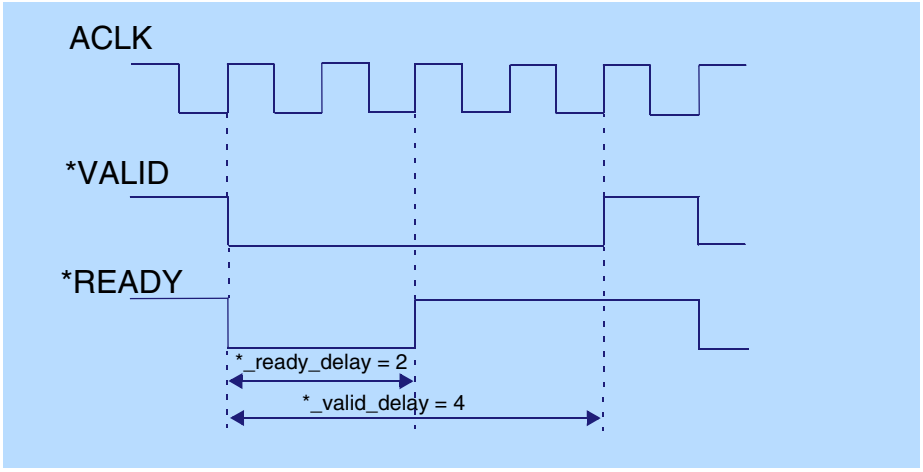
The default configuration (*delay_mode = AXI_VALID2READY*) corresponds to the delay measured from the positive edge of *ACLK* when **VALID* is asserted in a transaction. Figure 7-3 demonstrates how to achieve a **VALID* asserted before **READY* handshake.

**Figure 7-3. Operational Transaction Field delay_mode = AXI_VALID2READY**




The other configuration (*delay_mode = AXI_TRANS2READY*) corresponds to the delay measured from the completion of a previous transaction phase (**VALID* and **READY* both asserted). Figure 7-4 demonstrates how to achieve a **READY* before **VALID* handshake.

**Figure 7-4. Operational Transaction Field delay_mode = AXI_TRANS2READY**



## Data Beat Done

There is a *data_beat_done* transaction field in each transaction, defined as an array, to indicate when each data phase (beat) has completed. Each element of the *data_beat_done* array is set to 1 when each data phase (beat) has completed in a data burst.

You call the *get_data_beat_done()* procedure in the master BFM test program to determine how many beats of a read data burst have completed by analyzing how many elements of the *data_beat_done* array have been set to 1. Similarly, the *get_data_beat_done()* procedure can be called in the slave BFM test program to analyze a write data burst.

## Transaction Done

There is a *transaction_done* transaction field in each transaction which indicates when the transaction has completed.

In a BFM test program, you call the respective BFM *get_transaction_done()* procedure to investigate whether a read or write transaction has completed.

# Chapter 8
# VHDL AXI3 and AXI4 Master BFMs

This section provides information about the VHDL AXI3 and AXI4 master BFMs. Each BFM has an API that contains procedures to configure the BFM and to access the dynamic Transaction Record during the life of the transaction.

**Note**

Due to AXI3 protocol specification changes, for some BFM procedures, you reference the AXI3 BFM by specifying AXI instead of AXI3.

## Overloaded Procedure Common Arguments

The BFMs use VHDL procedure overloading, which results in the prototype having a number of prototype definitions for each procedure. Their arguments are unique to each procedure and concern the protocol or operational transaction fields for a transaction. These procedures have several common arguments which can be optional and include the arguments described below:

- *transaction_id* is an index number that identifies a specific transaction. Each new transaction automatically increments the index number until reaching 255, the maximum value, and then the index number automatically wraps to zero. The *transaction_id* uniquely identifies each transaction when there are a number of concurrently active transactions.
- *queue_id* is a unique identifier for each queue in a testbench. A queue is used to pass the record of a transaction between the address, data and response channels of a write transaction, and the address and data channels of a read transaction. *bfm_id* is a unique identification number for each master, slave, and monitor BFM in a multiple BFM testbench.
- *path_id* is a unique identifier for each parallel process in a multiple process testbench. You must specify the *path_id* for testbench stimulus to replicate the pipelining features of a protocol in a VHDL testbench. If no pipelining is performed in the testbench stimulus (a single process), then specifying the *path_id* argument for the procedure is optional.
- *tr_if* is a signal definition that passes the content of a transaction between the VHDL and SystemVerilog environments.

# Master BFM Protocol Support

The AXI3 master BFM supports the AMBA AXI3 protocol with restrictions detailed in "Protocol Restrictions" on page 1. In addition to the standard protocol, it supports user sideband signals *AWUSER* and *ARUSER*.

The AXI4 master BFM supports the AMBA AXI4 protocol with restrictions detailed in "Protocol Restrictions" on page 1.

# Master Timing and Events

For detailed timing diagrams of the protocol bus activity and details of the following master BFM API timing and events, refer to the relevant AMBA AXI Protocol Specification chapter.

The AMBA AXI specification does not define any timescale or clock period with signal events sampled and driven at rising *ACLK* edges. Therefore, the master BFM does not contain any timescale, timeunit, or timeprecision declarations with the signal setup and hold times specified in units of simulator time-steps.

# Master BFM Configuration

The master BFM supports the full range of signals defined for the AMBA AXI protocol specification. It has parameters that can be used to configure the widths of the address, data and ID signals and transaction fields to configure timeout factors, slave exclusive support, setup and hold times, etc.

The address, data and ID signals widths can be changed from their default settings by assigning them with new values, usually performed in the top-level module of the testbench. These new values are then passed into the master BFM via a parameter port list of the master BFM component.

Table 8-1 lists the parameter names for the address, data and ID signals, and their default values.

**Table 8-1. Master BFM Signal Width Parameters**

| Signal Width Parameter | Description |
|---|---|
| **_ADDRESS_WIDTH | Address signal width in bits. This applies to the *ARADDR* and *AWADDR* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 64. |
| **_RDATA_WIDTH | Read data signal width in bits. This applies to the *RDATA* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 1024. |
| **_WDATA_WIDTH | Write data signal width in bits. This applies to the *WDATA* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 1024. |

**Table 8-1. Master BFM Signal Width Parameters**

| Signal Width Parameter | Description |
|---|---|
| **_ID_WIDTH | ID signal width in bits. This applies to the *RID* and *WID* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 18. |
| AXI4_USER_WIDTH | (AXI4) User data signal width in bits. This applies to the *ARUSER*, *AWUSER*, *RUSER*, *WUSER* and *BUSER* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 8. |
| AXI4_REGION_MAP_SIZE | (AXI4) Region signal width in bits. This applies to the *ARREGION* and *AWREGION* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 16. |

A master BFM has configuration fields that you can set via the *set_config()* function to configure timeout factors, slave exclusive support, setup and hold times, etc. You can also get the value of a configuration field via the *get_config()* procedures. The full list of configuration fields is described in Table 8-2 below.

**Table 8-2. Master BFM Configuration**

| Configuration Field | Description |
|---|---|
| **Timing Variables** | |
| **_CONFIG_SETUP_TIME | The setup-time prior to the active edge of ACLK, in units of simulator time-steps for all signals.[1] Default: 0. |
| **_CONFIG_HOLD_TIME | The hold-time after the active edge of ACLK, in units of simulator time-steps for all signals.[1] Default: 0. |
| AXI_CONFIG_MAX_TRANSACTION_TIME_FACTOR | (AXI3) The maximum timeout duration for a read/write transaction in clock cycles. Default: 100000. |
| AXI_CONFIG_TIMEOUT_MAX_DATA_TRANSFER | (AXI3) The maximum number of write data beats that the AXI3 BFM can generate as part of write data burst of write transfer. Default: 1024. |
| **_CONFIG_BURST_TIMEOUT_FACTOR | The maximum delay between the individual phases of a read/write transaction in clock cycles. Default: 10000. |
| AXI4_CONFIG_MAX_LATENCY_AWVALID_ ASSERTION_TO_AWREADY | (AXI4) The maximum timeout duration from the assertion of *AWVALID* to the assertion of *AWREADY* in clock periods (default 10000). |
| AXI4_CONFIG_MAX_LATENCY_ARVALID_ ASSERTION_TO_ARREADY | (AXI4) The maximum timeout duration from the assertion of *ARVALID* to the assertion of *ARREADY* in clock periods (default 10000). |
| AXI4_CONFIG_MAX_LATENCY_RVALID_ ASSERTION_TO_RREADY | (AXI4) The maximum timeout duration from the assertion of *RVALID* to the assertion of *RREADY* in clock periods (default 10000). |

**Table 8-2. Master BFM Configuration**

| Configuration Field | Description |
|---|---|
| **Timing Variables** | |
| AXI4_CONFIG_MAX_LATENCY_BVALID_ ASSERTION_TO_BREADY | (AXI4) The maximum timeout duration from the assertion of *BVALID* to the assertion of *BREADY* in clock periods (default 10000). |
| AXI4_CONFIG_MAX_LATENCY_WVALID_ ASSERTION_TO_WREADY | (AXI4) The maximum timeout duration from the assertion of *WVALID* to the assertion of *WREADY* in clock periods (default 10000). |
| **Master Attributes** | |
| AXI_CONFIG_WRITE_CTRL_TO_DATA_MINTIME | (AXI3) The minimum delay from the start of a write control (address) phase to the start of a write data phase in clock cycles. Default: 1. |
| AXI_CONFIG_MASTER_WRITE_DELAY | (AXI3) The master BFM applies the AXI_CONFIG_WRITE_CTRL_TO_ DATA_MINTIME value set.<br>0 = true (default)<br>1 = false |
| AXI_CONFIG_MASTER_DEFAULT_UNDER_RESET | (AXI3) The master BFM drives the *ARVALID*, *AWVALID* and *WVALID* signals low during reset:<br>0 = false (default)<br>1 = true |
| AXI4_CONFIG_ENABLE_QOS | (AXI4) The master participates in the Quality-of-Service scheme. If a master does not participate, the *AWQOS/ARQOS* value used in write/read transactions must be b0000. |
| **Slave Attributes** | |
| **_CONFIG_SUPPORT_EXCLUSIVE_ACCESS | Configures the support for an exclusive slave. If enabled the BFM will expect an *EXOKAY* response to a successful exclusive transaction. If disabled the BFM will expect an *OKAY* response to an exclusive transaction. Refer to the AMBA AXI protocol specification for more details.<br>0 = disabled<br>1 = enabled (default) |
| AXI_CONFIG_SLAVE_DEFAULT_UNDER_RESET | (AXI3) The slave BFM drives the *BVALID* and *RVALID* signals low during reset. Refer to the AMBA AXI Protocol specification for more details.<br>0 = false (default)<br>1 = true |
| AXI4_CONFIG_SLAVE_START_ADDR | (AXI4) Configures the start address map for the slave. |
| AXI4_CONFIG_SLAVE_END_ADDR | (AXI4) Configures the end address map for the slave. |

**Table 8-2. Master BFM Configuration**

| Configuration Field | Description |
|---|---|
| **Slave Attributes** | |
| AXI4_CONFIG_READ_DATA_REORDERING_DEPTH | (AXI4) The slave read reordering depth. Refer to the AMBA AXI Protocol specification for more details. Default: 1. |
| **Error Detection** | |
| **_CONFIG_ENABLE_ALL_ASSERTIONS | Global enable/disable of all assertion checks in the BFM.<br>0 = disabled<br>1 = enabled (default) |

[1.] Refer to Master Timing and Events for details of simulator time-steps.

# Master Assertions

Each master BFM performs protocol error checking via built-in assertions.

**Note**
The built-in BFM assertions are independent of programming language and simulator.

## AXI3 Assertion Configuration

By default all built-in assertions are enabled in the master BFM. To globally disable them in the master BFM, use the *set_config()* command as the following example illustrates.

```
set_config(AXI_CONFIG_ENABLE_ALL_ASSERTIONS,0,bfm_index,
axi_tr_if_0(bfm_index));
```

Alternatively, you can disable individual built-in assertions by using a sequence of *get_config()* and *set_config()* commands on the respective assertion. For example, to disable assertion checking for the *AWLOCK* signal changing between the *AWVALID* and *AWREADY* handshake signals, use the following sequence of commands:

```
-- Define a local bit vector to hold the value of the assertion bit vector
variable config_assert_bitvector : std_logic_vector(AXI_MAX_BIT_SIZE-1
downto 0);

-- Get the current value of the assertion bit vector
get_config(AXI_CONFIG_ENABLE_ASSERTION, config_assert_bitvector,
bfm_index, axi_tr_if_0(bfm_index));

-- Assign the AXI_LOCK_CHANGED_BEFORE_AWREADY assertion bit to 0
config_assert_bitvector(AXI_LOCK_CHANGED_BEFORE_AWREADY) := '0';

-- Set the new value of the assertion bit vector
set_config(AXI_CONFIG_ENABLE_ASSERTION, config_assert_bitvector,
bfm_index, axi_tr_if_0(bfm_index));
```

**Note**

Do not confuse the *AXI_CONFIG_ENABLE_ASSERTION* bit vector with the *AXI_CONFIG_ENABLE_ALL_ASSERTIONS* global enable/disable.

To re-enable the *AXI_LOCK_CHANGED_BEFORE_AWREADY* assertion, follow the above code sequence and assign the assertion in the *AXI_CONFIG_ENABLE_ASSERTION* bit vector to 1.

For a complete listing of assertions, refer to "AXI3 Assertions" on page 641.

## AXI4 Assertion Configuration

By default all built-in assertions are enabled in the master BFM. To globally disable them in the master BFM, use the *set_config()* command as the following example illustrates.

```
set_config(AXI4_CONFIG_ENABLE_ALL_ASSERTIONS,0,bfm_index,
axi4_tr_if_0(bfm_index));
```

Alternatively, you can disable individual built-in assertions by using a sequence of *get_config()* and *set_config()* commands on the respective assertion. For example, to disable assertion checking for the *AWLOCK* signal changing between the *AWVALID* and *AWREADY* handshake signals, use the following sequence of commands:

```
-- Define a local bit vector to hold the value of the assertion bit vector
variable config_assert_bitvector : std_logic_vector(AXI4_MAX_BIT_SIZE-1
downto 0);

-- Get the current value of the assertion bit vector
get_config(AXI4_CONFIG_ENABLE_ASSERTION, config_assert_bitvector,
bfm_index, axi4_tr_if_0(bfm_index));

-- Assign the AXI4_LOCK_CHANGED_BEFORE_AWREADY assertion bit to 0
config_assert_bitvector(AXI4_LOCK_CHANGED_BEFORE_AWREADY) := '0';

-- Set the new value of the assertion bit vector
set_config(AXI4_CONFIG_ENABLE_ASSERTION, config_assert_bitvector,
bfm_index, axi4_tr_if_0(bfm_index));
```

**Note**

Do not confuse the *AXI4_CONFIG_ENABLE_ASSERTION* bit vector with the *AXI4_CONFIG_ENABLE_ALL_ASSERTIONS* global enable/disable.

To re-enable the *AXI4_LOCK_CHANGED_BEFORE_AWREADY* assertion, follow the above code sequence and assign the assertion in the *AXI4_CONFIG_ENABLE_ASSERTION* bit vector to 1.

For a complete listing of assertions, refer to "AXI4 Assertions" on page 654.

# VHDL Master API

This section describes the VHDL Master API.

## set_config()

This nonblocking procedure sets the configuration of the master BFM.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure set_config
(
   config_name    : in std_logic_vector(7 downto 0);
   config_val     : in std_logic_vector(**_MAX_BIT_SIZE-1 downto
   0)|integer;
   bfm_id         : in integer;
   path_id        : in *_path_t; -- optional
   signal tr_if   : inout *_vhd_if_struct_t
);
```

**Arguments**

config_name — (AXI3) Configuration name:

- AXI_CONFIG_SETUP_TIME
- AXI_CONFIG_HOLD_TIME
- AXI_CONFIG_MAX_TRANSACTION_TIME_FACTOR
- AXI_CONFIG_TIMEOUT_MAX_DATA_TRANSFER
- AXI_CONFIG_BURST_TIMEOUT_FACTOR
- AXI_CONFIG_WRITE_CTRL_TO_DATA_MINTIME
- AXI_CONFIG_MASTER_WRITE_DELAY
- AXI_CONFIG_MASTER_DEFAULT_UNDER_RESET
- AXI_CONFIG_SLAVE_DEFAULT_UNDER_RESET
- AXI_CONFIG_ENABLE_ALL_ASSERTIONS
- AXI_CONFIG_MASTER_ERROR_POSITION
- AXI_CONFIG_SUPPORT_EXCLUSIVE_ACCESS

(AXI4) Configuration name:

- AXI4_CONFIG_SETUP_TIME
- AXI4_CONFIG_HOLD_TIME
- AXI4_CONFIG_BURST_TIMEOUT_FACTOR
- AXI4_CONFIG_ENABLE_RLAST
- AXI4_CONFIG_ENABLE_SLAVE_EXCLUSIVE
- AXI4_CONFIG_ENABLE_ALL_ASSERTIONS
- AXI4_CONFIG_ENABLE_ASSERTION
- AXI4_CONFIG_MAX_LATENCY_AWVALID_ASSERTION_TO_AWREADY
- AXI4_CONFIG_MAX_LATENCY_ARVALID_ASSERTION_TO_ARREADY
- AXI4_CONFIG_MAX_LATENCY_RVALID_ASSERTION_TO_RREADY
- AXI4_CONFIG_MAX_LATENCY_BVALID_ASSERTION_TO_BREADY
- AXI4_CONFIG_MAX_LATENCY_WVALID_ASSERTION_TO_WREADY
- AXI4_CONFIG_ENABLE_QOS
- AXI4_CONFIG_READ_DATA_REORDERING_DEPTH
- AXI4_CONFIG_SLAVE_START_ADDR
- AXI4_CONFIG_SLAVE_END_ADDR

config_val — Refer to "Master BFM Configuration" on page 188 for description and valid values.

| | |
|---|---|
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
set_config(AXI_CONFIG_SUPPORT_EXCLUSIVE_ACCESS, 1, bfm_index,
      axi_tr_if_0(bfm_index));
set_config(AXI_CONFIG_BURST_TIMEOUT_FACTOR, 1000, bfm_index,
      axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
set_config(AXI4_CONFIG_SUPPORT_EXCLUSIVE_ACCESS, 1, bfm_index,
      axi4_tr_if_0(bfm_index));
set_config(AXI4_CONFIG_BURST_TIMEOUT_FACTOR, 1000, bfm_index,
      axi4_tr_if_0(bfm_index));
```

# get_config()

This nonblocking procedure gets the configuration of the master BFM.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure get_config
(
   config_name    : in std_logic_vector(7 downto 0);
   config_val     : out std_logic_vector(**_MAX_BIT_SIZE-1 downto
   0)|integer;
   bfm_id         : in integer;
   path_id        : in *_path_t; --optional
   signal tr_if   : inout *_vhd_if_struct_t
);
```

**Arguments**

config_name — (AXI3) Configuration name:

- AXI_CONFIG_SETUP_TIME
- AXI_CONFIG_HOLD_TIME
- AXI_CONFIG_MAX_TRANSACTION_TIME_FACTOR
- AXI_CONFIG_TIMEOUT_MAX_DATA_TRANSFER
- AXI_CONFIG_BURST_TIMEOUT_FACTOR
- AXI_CONFIG_WRITE_CTRL_TO_DATA_MINTIME
- AXI_CONFIG_MASTER_WRITE_DELAY
- AXI_CONFIG_MASTER_DEFAULT_UNDER_RESET
- AXI_CONFIG_SLAVE_DEFAULT_UNDER_RESET
- AXI_CONFIG_ENABLE_ALL_ASSERTIONS
- AXI_CONFIG_MASTER_ERROR_POSITION
- AXI_CONFIG_SUPPORT_EXCLUSIVE_ACCESS

(AXI4) Configuration name:

- AXI4_CONFIG_SETUP_TIME
- AXI4_CONFIG_HOLD_TIME
- AXI4_CONFIG_BURST_TIMEOUT_FACTOR
- AXI4_CONFIG_ENABLE_RLAST
- AXI4_CONFIG_ENABLE_SLAVE_EXCLUSIVE
- AXI4_CONFIG_ENABLE_ALL_ASSERTIONS
- AXI4_CONFIG_ENABLE_ASSERTION
- AXI4_CONFIG_MAX_LATENCY_AWVALID_ASSERTION_TO_AWREADY
- AXI4_CONFIG_MAX_LATENCY_ARVALID_ASSERTION_TO_ARREADY
- AXI4_CONFIG_MAX_LATENCY_RVALID_ASSERTION_TO_RREADY
- AXI4_CONFIG_MAX_LATENCY_BVALID_ASSERTION_TO_BREADY
- AXI4_CONFIG_MAX_LATENCY_WVALID_ASSERTION_TO_WREADY
- AXI4_CONFIG_ENABLE_QOS
- AXI4_CONFIG_READ_DATA_REORDERING_DEPTH
- AXI4_CONFIG_SLAVE_START_ADDR
- AXI4_CONFIG_SLAVE_END_ADDR

config_val — Refer to "Master BFM Configuration" on page 188 for description and valid values.

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

| | | |
|---|---|---|
| | path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| | tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| **Returns** | config_val | |

## AXI3 Example

```
get_config(AXI_CONFIG_SUPPORT_EXCLUSIVE_ACCESS, config_value, bfm_index,
     axi_tr_if_0(bfm_index));
get_config(AXI_CONFIG_BURST_TIMEOUT_FACTOR, config_value, bfm_index,
     axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
get_config(AXI4_CONFIG_SUPPORT_EXCLUSIVE_ACCESS, config_value,
     bfm_index, axi4_tr_if_0(bfm_index));
get_config(AXI4_CONFIG_BURST_TIMEOUT_FACTOR, config_value, bfm_index,
     axi4_tr_if_0(bfm_index));
```

# create_write_transaction()

This nonblocking procedure creates a write transaction with a start address *addr* and optional *burst_length* arguments. All other transaction fields default to legal protocol values, unless previously assigned a value. It returns with the *transaction_id* argument.

## Prototype

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure create_write_transaction
(
   addr            : in std_logic_vector(**_MAX_BIT_SIZE-1 downto
   0)|integer;
   burst_length     : in integer; --optional
   transaction_id   : out integer;
   bfm_id           : in integer;
   path_id          : in *_path_t; --optional
   signal tr_if     : inout *_vhd_if_struct_t
);
```

## Arguments

| | |
|---|---|
| addr | Start address |
| burst_length | (Optional) Burst length. Default: 0. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

## Protocol Transaction Fields

| | |
|---|---|
| size | Burst size. Default: width of bus:<br>**_BYTES_1;<br>**_BYTES_2;<br>**_BYTES_4;<br>**_BYTES_8;<br>**_BYTES_16;<br>**_BYTES_32;<br>**_BYTES_64;<br>**_BYTES_128; |
| burst | Burst type:<br>**_FIXED;<br>**_INCR; (default)<br>**_WRAP;<br>**_BURST_RSVD; |

**Protocol Transaction Fields**

| | |
|---|---|
| lock | Burst lock:<br>**_NORMAL; (default)<br>**_EXCLUSIVE;<br>(AXI3) AXI_LOCKED;<br>(AXI3) AXI_LOCK_RSVD; |
| cache | (AXI3) Burst cache:<br>AXI_NONCACHE_NONBUF; (default)<br>AXI_BUF_ONLY;<br>AXI_CACHE_NOALLOC;<br>AXI_CACHE_BUF_NOALLOC;<br>AXI_CACHE_RSVD0;<br>AXI_CACHE_RSVD1;<br>AXI_CACHE_WTHROUGH_ALLOC_R_ONLY;<br>AXI_CACHE_WBACK_ALLOC_R_ONLY;<br>AXI_CACHE_RSVD2;<br>AXI_CACHE_RSVD3;<br>AXI_CACHE_WTHROUGH_ALLOC_W_ONLY;<br>AXI_CACHE_WBACK_ALLOC_W_ONLY;<br>AXI_CACHE_RSVD4;<br>AXI_CACHE_RSVD5;<br>AXI_CACHE_WTHROUGH_ALLOC_RW;<br>AXI_CACHE_WBACK_ALLOC_RW;<br><br>(AXI4) Burst cache:<br>AXI4_NONMODIFIABLE_NONBUF; (default)<br>AXI4_BUF_ONLY;<br>AXI4_CACHE_NOALLOC;<br>AXI4_CACHE_2;<br>AXI4_CACHE_3;<br>AXI4_CACHE_RSVD4;<br>AXI4_CACHE_RSVD5;<br>AXI4_CACHE_6;<br>AXI4_CACHE_7;<br>AXI4_CACHE_RSVD8;<br>AXI4_CACHE_RSVD9;<br>AXI4_CACHE_10;<br>AXI4_CACHE_11;<br>AXI4_CACHE_RSVD12;<br>AXI4_CACHE_RSVD12;<br>AXI4_CACHE_14;<br>AXI4_CACHE_15; |
| prot | Burst protection:<br>**_NORM_SEC_DATA; (default)<br>**_PRIV_SEC_DATA;<br>**_NORM_NONSEC_DATA;<br>**_PRIV_NONSEC_DATA;<br>**_NORM_SEC_INST;<br>**_PRIV_SEC_INST;<br>**_NORM_NONSEC_INST;<br>**_PRIV_NONSEC_INST; |
| id | Burst ID. |
| data_words | Data words array. |
| write_strobes | Write strobes array:<br>Each strobe 0 or 1. |

| | | |
|---|---|---|
| **Protocol Transaction Fields** | resp | Burst response:<br>**_OKAY;<br>**_EXOKAY;<br>**_SLVERR;<br>**_DECERR; |
| | region | (AXI4) Region identifier. |
| | qos | (AXI4) Quality-of-Service identifier. |
| | addr_user | Address channel user data. |
| | data_user | (AXI4) Data channel user data. |
| | resp_user | (AXI4) Response channel user data. |
| **Operational Transaction Fields** | gen_write_strobes | Correction of write strobes for invalid byte lanes:<br>0 = write_strobes passed through to protocol signals.<br>1 = write_strobes auto-corrected for invalid byte lanes (default). |
| | operation_mode | Operation mode:<br>**_TRANSACTION_NON_BLOCKING;<br>**_TRANSACTION_BLOCKING; (default) |
| | delay_mode | (AXI3) Delay mode:<br>AXI_VALID2READY; (default)<br>AXI_TRANS2READY; |
| | write_data_mode | Write data mode:<br>**_DATA_AFTER_ADDRESS; (default)<br>**_DATA_WITH_ADDRESS; |
| | address_valid_delay | Address channel *A*VALID* delay measured in *ACLK* cycles for this transaction (default = 0). |
| | data_valid_delay | Write data channel *WVALID* delay array measured in *ACLK* cycles for this transaction (default = 0 for all elements). |
| | write_response_read_delay | Write response channel *BREADY* delay measured in *ACLK* cycles for this transaction (default = 0). |
| | data_beat_done | Write data channel beat *done* flag array for this transaction. |
| | transaction_done | Write transaction *done* flag for this transaction. |
| **Returns** | transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187. |

## AXI3 Example

```
-- Create a write data burst of length 3 (4 beats) to start address 16.
-- Returns the transaction ID (tr_id) for this created transaction.
create_write_transaction(16, 3, tr_id, bfm_index,
      axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write data burst of length 3 (4 beats) to start address 16.
-- Returns the transaction ID (tr_i d) for this created transaction.
create_write_transaction(16, 3, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# create_read_transaction()

This nonblocking procedure creates a read transaction with a start address *addr* and optional *burst_length* arguments. All other transaction parameters default to legal protocol values, unless previously assigned a value. It returns with the *transaction_id* argument.

## Prototype

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure create_read_transaction
(
   addr             : in std_logic_vector(**_MAX_BIT_SIZE-1
   downto 0)|integer;
   burst_length     : in integer; --optional
   transaction_id   : out integer;
   bfm_id           : in integer;
   path_id          : in *_path_t; --optional
   signal tr_if     : inout *_vhd_if_struct_t
);
```

## Arguments

| | |
|---|---|
| addr | Start address |
| burst_length | (Optional) Burst length. Default: 0. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

## Protocol Transaction Fields

| | |
|---|---|
| size | Burst size. Default: width of bus:<br>**_BYTES_1;<br>**_BYTES_2;<br>**_BYTES_4;<br>**_BYTES_8;<br>**_BYTES_16;<br>**_BYTES_32;<br>**_BYTES_64;<br>**_BYTES_128; |
| burst | Burst type:<br>**_FIXED;<br>**_INCR; (default)<br>**_WRAP;<br>**_BURST_RSVD; |

### Protocol Transaction Fields

| | |
|---|---|
| lock | Burst lock:<br>**_NORMAL; (default)<br>**_EXCLUSIVE;<br>(AXI3) AXI_LOCKED;<br>(AXI3) AXI_LOCK_RSVD; |
| cache | (AXI3) Burst cache:<br>AXI_NONCACHE_NONBUF; (default)<br>AXI_BUF_ONLY;<br>AXI_CACHE_NOALLOC;<br>AXI_CACHE_BUF_NOALLOC;<br>AXI_CACHE_RSVD0;<br>AXI_CACHE_RSVD1;<br>AXI_CACHE_WTHROUGH_ALLOC_R_ONLY;<br>AXI_CACHE_WBACK_ALLOC_R_ONLY;<br>AXI_CACHE_RSVD2;<br>AXI_CACHE_RSVD3;<br>AXI_CACHE_WTHROUGH_ALLOC_W_ONLY;<br>AXI_CACHE_WBACK_ALLOC_W_ONLY;<br>AXI_CACHE_RSVD4;<br>AXI_CACHE_RSVD5;<br>AXI_CACHE_WTHROUGH_ALLOC_RW;<br>AXI_CACHE_WBACK_ALLOC_RW;<br><br>(AXI4) Burst cache:<br>AXI4_NONMODIFIABLE_NONBUF; (default)<br>AXI4_BUF_ONLY;<br>AXI4_CACHE_NOALLOC;<br>AXI4_CACHE_2;<br>AXI4_CACHE_3;<br>AXI4_CACHE_RSVD4;<br>AXI4_CACHE_RSVD5;<br>AXI4_CACHE_6;<br>AXI4_CACHE_7;<br>AXI4_CACHE_RSVD8;<br>AXI4_CACHE_RSVD9;<br>AXI4_CACHE_10;<br>AXI4_CACHE_11;<br>AXI4_CACHE_RSVD12;<br>AXI4_CACHE_RSVD12;<br>AXI4_CACHE_14;<br>AXI4_CACHE_15; |
| prot | Burst protection:<br>**_NORM_SEC_DATA; (default)<br>**_PRIV_SEC_DATA;<br>**_NORM_NONSEC_DATA;<br>**_PRIV_NONSEC_DATA;<br>**_NORM_SEC_INST;<br>**_PRIV_SEC_INST;<br>**_NORM_NONSEC_INST;<br>**_PRIV_NONSEC_INST; |
| id | Burst ID. |
| data_words | Data words array. |
| resp | Burst response:<br>**_OKAY;<br>**_EXOKAY;<br>**_SLVERR;<br>**_DECERR; |

| | | |
|---|---|---|
| **Operational Transaction Fields** | operation_mode | Operation mode:<br>**_TRANSACTION_NON_BLOCKING;<br>**_TRANSACTION_BLOCKING; (default) |
| | delay_mode | (AXI3) Delay mode:<br>AXI_VALID2READY; (default)<br>AXI_TRANS2READY; |
| | address_valid_delay | Address channel *A*VALID* delay measured in *ACLK* cycles for this transaction (default = 0). |
| | data_ready_delay | Read data channel *RREADY* delay array measured in *ACLK* cycles for this transaction (default = 0 for all elements). |
| | data_beat_done | Write data channel beat *done* flag array for this transaction. |
| | transaction_done | Read transaction *done* flag for this transaction. |
| **Returns** | transaction_id | |

## AXI3 Example

```
-- Create a read data burst of length 3 (4 beats) with start address 16.
-- Returns the transaction ID (tr_id) for this created transaction.
create_read_transaction(16, 3, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read data burst of length 3 (4 beats) with start address 16.
-- Returns the transaction ID (tr_id) for this created transaction.
create_read_transaction(16, 3, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_addr()

This nonblocking procedure sets the start address *addr* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_addr
(
   addr : in std_logic_vector(**_MAX_BIT_SIZE-1 downto 0) |
   integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| addr | Start address of transaction. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187. for more details |

**Returns**

None

## AXI3 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the start address to 1 for the tr_id transaction
set_addr(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the start address to 1 for the tr_id transaction
set_addr(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_addr()

This nonblocking procedure gets the start address *addr* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_addr
(
   addr : out std_logic_vector(**_MAX_BIT_SIZE-1 downto 0) |
   integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| addr | Start address of transaction. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

addr

## AXI3 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the start address addr of the tr_id transaction
get_addr(addr, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the start address addr of the tr_id transaction
get_addr(addr, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_size()

This nonblocking procedure sets the burst *size* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_size
(
   size : in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| size | Burst size. Default: width of bus:<br>**_BYTES_1;<br>**_BYTES_2;<br>**_BYTES_4;<br>**_BYTES_8;<br>**_BYTES_16;<br>**_BYTES_32;<br>**_BYTES_64;<br>**_BYTES_128; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the burst size to 4 bytes for the tr_id transaction
set_size (AXI_BYTES_4, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the burst size to 4 bytes for the tr_id transaction
set_size (AXI4_BYTES_4, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_size()

This nonblocking procedure gets the burst *size* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_size
(
   size : out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| size | Burst size:<br>**_BYTES_1;<br>**_BYTES_2;<br>**_BYTES_4;<br>**_BYTES_8;<br>**_BYTES_16;<br>**_BYTES_32;<br>**_BYTES_64;<br>**_BYTES_128; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to for more details. |
| path_id | (Optional) Parallel process path identifier of type<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** size

## AXI3 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the burst size of the tr_id transaction.
get_size (size, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the burst size of the tr_id transaction.
get_size (size, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_burst()

This nonblocking procedure sets the *burst* type field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the create_write_transaction() or create_read_transaction() procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_burst
(
   burst: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| burst | Burst type:<br>**_FIXED;<br>**_INCR (default);<br>**_WRAP;<br>**_BURST_RSVD; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the burst type to wrap for the tr_id transaction.
set_burst (AXI_WRAP, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the burst type to wrap for the tr_id transaction.
set_burst (AXI4_WRAP, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_burst()

This nonblocking procedure gets the *burst* type field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_burst
(
   burst: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| burst | Burst type:<br>**_FIXED;<br>**_INCR;<br>**_WRAP;<br>**_BURST_RSVD; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

burst

## AXI3 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the burst type of the tr_id transaction.
get_burst (burst, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the burst type of the tr_id transaction.
get_burst (burst, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_lock()

This nonblocking procedure sets the *lock* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_lock
(
   lock : in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| lock | Burst lock:<br>**_NORMAL (default);<br>**_EXCLUSIVE;<br>(AXI3) AXI_LOCKED;<br>(AXI3) AXI_LOCK_RSVD; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the lock field to exclusive for the tr_id transaction.
set_lock(AXI_EXCLUSIVE, tr_id, bfm_index, axi_tr_if_0(bfm_index))
```

## AXI4 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the lock field to exclusive for the tr_id transaction.
set_lock(AXI4_EXCLUSIVE, tr_id, bfm_index, axi4_tr_if_0(bfm_index))
```

# get_lock()

This nonblocking procedure gets the *lock* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_lock
(
   lock : out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| lock | Burst lock:<br>**_NORMAL;<br>**_EXCLUSIVE;<br>(AXI3) AXI_LOCKED;<br>(AXI3) AXI_LOCK_RSVD; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

lock

## AXI3 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the lock field of the tr_id transaction.
get_lock(lock, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the lock field of the tr_id transaction.
get_lock(lock, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_cache()

This nonblocking procedure sets the *cache* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_cache
(
   cache: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

cache — (AXI3) Burst cache:
- AXI_NONCACHE_NONBUF; (default)
- AXI_BUF_ONLY;
- AXI_CACHE_NOALLOC;
- AXI_CACHE_BUF_NOALLOC;
- AXI_CACHE_RSVD0;
- AXI_CACHE_RSVD1;
- AXI_CACHE_WTHROUGH_ALLOC_R_ONLY;
- AXI_CACHE_WBACK_ALLOC_R_ONLY;
- AXI_CACHE_RSVD2;
- AXI_CACHE_RSVD3;
- AXI_CACHE_WTHROUGH_ALLOC_W_ONLY;
- AXI_CACHE_WBACK_ALLOC_W_ONLY;
- AXI_CACHE_RSVD4;
- AXI_CACHE_RSVD5;
- AXI_CACHE_WTHROUGH_ALLOC_RW;
- AXI_CACHE_WBACK_ALLOC_RW;

(AXI4) Burst cache:
- AXI4_NONMODIFIABLE_NONBUF; (default)
- AXI4_BUF_ONLY;
- AXI4_CACHE_NOALLOC;
- AXI4_CACHE_2;
- AXI4_CACHE_3;
- AXI4_CACHE_RSVD4;
- AXI4_CACHE_RSVD5;
- AXI4_CACHE_6;
- AXI4_CACHE_7;
- AXI4_CACHE_RSVD8;
- AXI4_CACHE_RSVD9;
- AXI4_CACHE_10;
- AXI4_CACHE_11;
- AXI4_CACHE_RSVD12;
- AXI4_CACHE_RSVD12;
- AXI4_CACHE_14;
- AXI4_CACHE_15;

transaction_id — Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

| | |
|---|---|
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the cache field to bufferable only for the tr_id transaction.
set_cache(AXI_BUF_ONLY, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the tran4saction.
create_read_transaction(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the cache field to bufferable only for the tr_id transaction.
set_cache(AXI4_BUF_ONLY, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_cache()

This nonblocking procedure gets the *cache* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_cache
(
   cache: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

cache

(AXI3) Burst cache:
- AXI_NONCACHE_NONBUF; (default)
- AXI_BUF_ONLY;
- AXI_CACHE_NOALLOC;
- AXI_CACHE_BUF_NOALLOC;
- AXI_CACHE_RSVD0;
- AXI_CACHE_RSVD1;
- AXI_CACHE_WTHROUGH_ALLOC_R_ONLY;
- AXI_CACHE_WBACK_ALLOC_R_ONLY;
- AXI_CACHE_RSVD2;
- AXI_CACHE_RSVD3;
- AXI_CACHE_WTHROUGH_ALLOC_W_ONLY;
- AXI_CACHE_WBACK_ALLOC_W_ONLY;
- AXI_CACHE_RSVD4;
- AXI_CACHE_RSVD5;
- AXI_CACHE_WTHROUGH_ALLOC_RW;
- AXI_CACHE_WBACK_ALLOC_RW;

(AXI4) Burst cache:
- AXI4_NONMODIFIABLE_NONBUF; (default)
- AXI4_BUF_ONLY;
- AXI4_CACHE_NOALLOC;
- AXI4_CACHE_2;
- AXI4_CACHE_3;
- AXI4_CACHE_RSVD4;
- AXI4_CACHE_RSVD5;
- AXI4_CACHE_6;
- AXI4_CACHE_7;
- AXI4_CACHE_RSVD8;
- AXI4_CACHE_RSVD9;
- AXI4_CACHE_10;
- AXI4_CACHE_11;
- AXI4_CACHE_RSVD12;
- AXI4_CACHE_RSVD12;
- AXI4_CACHE_14;
- AXI4_CACHE_15;

transaction_id — Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

| | | |
|---|---|---|
| | path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| | tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| **Returns** | cache | |

## AXI3 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the cache field of the tr_id transaction.
get_cache(cache, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the cache field of the tr_id transaction.
get_cache(cache, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_prot()

This nonblocking procedure sets the protection *prot* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_prot
(
   prot: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| prot | Burst protection:<br>**_NORM_SEC_DATA (default);<br>**_PRIV_SEC_DATA;<br>**_NORM_NONSEC_DATA;<br>**_PRIV_NONSEC_DATA;<br>**_NORM_SEC_INST;<br>**_PRIV_SEC_INST;<br>**_NORM_NONSEC_INST;<br>**_PRIV_NONSEC_INST; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the protection field to a normal, secure, instruction access
-- for the tr_id transaction.
set_prot(AXI_NORM_SEC_INST, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the protection field to a normal, secure, instruction access
-- for the tr_id transaction.
set_prot(AXI4_NORM_SEC_INST, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_prot()

This nonblocking procedure gets the protection *prot* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_prot
(
   prot: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| prot | Burst protection:<br>**_NORM_SEC_DATA;<br>**_PRIV_SEC_DATA;<br>**_NORM_NONSEC_DATA;<br>**_PRIV_NONSEC_DATA;<br>**_NORM_SEC_INST;<br>**_PRIV_SEC_INST;<br>**_NORM_NONSEC_INST;<br>**_PRIV_NONSEC_INST; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** prot

## AXI3 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the protection field of the tr_id transaction.
get_prot(prot, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the protection field of the tr_id transaction.
get_prot(prot, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_id()

This nonblocking procedure sets the *id* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_id
(
   id: in integer;
   transaction_id  : in std_logic_vector(**_MAX_BIT_SIZE-1 downto
   0) | integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| id | Burst ID |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the id field to 2 for the tr_id transaction.
set_id(2, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the id field to 2 for the tr_id transaction.
```

```
set_id(2, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_id()

This nonblocking procedure gets the *id* field for a transaction, which uniquely identifies the transaction defined by the *transaction_id* field and previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_id
(
   id: out integer;
   transaction_id  : in std_logic_vector(**_MAX_BIT_SIZE-1 downto
   0) | integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| id | Burst ID |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** id

## AXI3 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the id field of the tr_id transaction.
get_id(id, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the id field of the tr_id transaction.
get_id(id, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_burst_length()

This nonblocking procedure sets the *burst_length* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Note**

The *burst_length* field is the value that appears on the *AWLEN* and the *ARLEN* protocol signals. The number of data phases (beats) in a data burst is therefore *burst_length* + 1.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_burst_length
(
  burst_length : in std_logic_vector(**_MAX_BIT_SIZE-1 downto 0) |
  integer;
  transaction_id  : in integer;
  bfm_id : in integer;
  path_id : in *_path_t; --optional
  signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| burst_length | Burst length. Default: 0. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the burst length field to 2 (3 beats) for the tr_id transaction.
set_burst_length(2, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the tran4saction.
create_read_transaction(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the burst length field to 2 (3 beats) for the tr_id transaction.
set_burst_length(2, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_burst_length()

This nonblocking procedure gets the *burst_length* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Note**

The *burst_length* field is the value that appears on the *AWLEN* and the *ARLEN* protocol signals. The number of data phases (beats) in a data burst is the *burst_length* + 1.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_burst_length
(
 burst_length : out std_logic_vector(**_MAX_BIT_SIZE-1 downto 0)
 | integer;
 transaction_id  : in integer;
 bfm_id : in integer;
 path_id : in *_path_t; --optional
 signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| burst_length | Burst length. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** burst_length

## AXI3 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the burst length field of the tr_id transaction.
get_burst_length(burst_length, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the burst length field of the tr_id transaction.
get_burst_length(burst_length, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_data_words()

This nonblocking procedure sets a *data_words* field array element for a write transaction that is uniquely identified by the *transaction_id* field previously created by the *create_write_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_data_words
(
   data_words: in std_logic_vector(**_MAX_BIT_SIZE-1 downto 0) |
   integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| data_words | Data words array. |
| index | (Optional) Array element index number for data_words. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a write transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the data_words field to 2 for the first write data phase (beat)
-- for the tr_id transaction.
set_data_words(2, 0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the data_words field to 3 for the second write data phase (beat)
-- for the tr_id transaction.
set_data_words(3, 1, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the data_words field to 2 for the first write data phase (beat)
-- for the tr_id transaction.
set_data_words(2, 0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the data_words field to 3 for the second write data phase (beat)
-- for the tr_id transaction.
set_data_words(3, 1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_data_words()

This nonblocking procedure gets a *data_words* field array element for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_data_words
(
   data_words: out std_logic_vector(**_MAX_BIT_SIZE-1 downto 0) |
   integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| data_words | Data words array. |
| index | (Optional) Array element index number for data_words. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** data_words

## AXI3 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Get the data_words field for the first data phase (beat)
-- of the tr_id transaction.
get_data_words(data, 0, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Get the data_words field for the first data phase (beat)
-- of the tr_id transaction.
get_data_words(data, 0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Get the data_words field for the second data phase (beat)
-- of the tr_id transaction.
get_data_words(data, 1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_write_strobes()

This nonblocking procedure sets the *write_strobes* field array elements for a write transaction that is uniquely identified by the *transaction_id* field previously created by the *create_write_transaction()* procedure.

**Prototype**

```
-- * = axi | axi4
-- ** = AXI | AXI4
set_write_strobes
(
   write_strobes : in std_logic_vector (**_MAX_BIT_SIZE-1 downto 0)
   | integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| write_strobes | Write strobes array. |
| index | (Optional) Array element index number for write_strobes. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a write transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the write_strobes field to for the first data phase (beat)
-- for the tr_id transaction.
set_write_strobes(2, 0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the write_strobes field to 12 for the second data phase (beat)
-- for the tr_id transaction.
set_write_strobes(12, 1, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the write_strobes field to for the first data phase (beat)
-- for the tr_id transaction.
set_write_strobes(2, 0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the write_strobes field to 12 for the second data phase (beat)
-- for the tr_id transaction.
set_write_strobes(12, 1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_write_strobes()

This nonblocking procedure gets a *write_strobes* field array element for a write transaction that is uniquely identified by the *transaction_id* field previously created by the *create_write_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_write_strobes
(
 write_strobes : out std_logic_vector (**_MAX_BIT_SIZE-1 downto 0)
 | integer;
 index : in integer; --optional
 transaction_id  : in integer;
 bfm_id : in integer;
 path_id : in *_path_t; --optional
 signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| write_strobes | Write strobes array. |
| index | (Optional) Array element index number fro write_strobes. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

write_strobes

## AXI3 Example

```
-- Create a write transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Get the write_strobes field for the first data phase (beat)
-- of the tr_id transaction.
get_write_strobes(write_strobe, 0, tr_id, bfm_index,
axi_tr_if_0(bfm_index));

-- Get the write_strobes field for the second data phase (beat)
-- of the tr_id transaction.
get_write_strobes(write_strobe, 1, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Get the write_strobes field for the first data phase (beat)
-- of the tr_id transaction.
get_write_strobes(write_strobe, 0, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));

-- Get the write_strobes field for the second data phase (beat)
-- of the tr_id transaction.
get_write_strobes(write_strobe, 1, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_resp()

This nonblocking procedure sets a response *resp* field array element for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_resp
(
   resp: in std_logic_vector (**_MAX_BIT_SIZE-1 downto 0) |
   integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| resp | Transaction response array:<br>**_OKAY = 0;<br>**_EXOKAY = 1;<br>**_SLVERR = 2;<br>**_DECERR = 3; |
| index | (Optional) Array element index number for resp. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You would not normally use this procedure in a master test program.

# get_resp()

This nonblocking procedure gets a response *resp* field array element for a transaction that is identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_resp
(
   resp: out std_logic_vector (**_MAX_BIT_SIZE-1 downto 0) |
   integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| resp | Transaction response array:<br><br>**_OKAY = 0;<br>**_EXOKAY = 1;<br>**_SLVERR = 2;<br>**_DECERR = 3; |
| index | (Optional) Array element index number for resp. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br><br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

resp

## AXI3 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the response field for the first data phase (beat)
-- of the tr_id transaction.
get_resp(read_resp, 0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Get the response field for the second data phase (beat)
-- of the tr_id transaction.
get_resp(read_resp, 1, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 1.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the response field for the first data phase (beat)
-- of the tr_id transaction.
get_resp(read_resp, 0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Get the response field for the second data phase (beat)
-- of the tr_id transaction.
get_resp(read_resp, 1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_addr_user()

This nonblocking procedure sets the user data *addr_user* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_addr_user
(
   addr_user : in std_logic_vector(**_MAX_BIT_SIZE-1 downto 0) |
   integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| addr_user | User data inin address phase. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the user data to 1 for tr_id transaction.
set_addr_user(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the user data to 1 for tr_id transaction.
set_addr_user(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_addr_user()

This nonblocking procedure gets the user data *addr_user* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_write_transaction()* or *create_read_transaction()* procedures.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_addr_user
(
   addr_user : out std_logic_vector(**_MAX_BIT_SIZE-1 downto 0) |
   integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| addr_user | User data in the address phase. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** addr_user

## AXI3 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the address channel user data of the tr_id transaction.
get_addr_user(user_data, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the address channel user data of the tr_id transaction.
get_addr_user(user_data, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_read_or_write()

This nonblocking procedure sets the *read_or_write* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_read_or_write
(
   read_or_write: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| read_or_write | Read or write transaction:<br>**_TRANS_READ = 0<br>**_TRANS_WRITE = 1 |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a master test program.

# get_read_or_write()

This nonblocking procedure gets the *read_or_write* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4 |
-- ** = AXI | AXI4
get_read_or_write
(
   read_or_write: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| read_or_write | Read or write transaction:<br>**_TRANS_READ = 0<br>**_TRANS_WRITE = 1 |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

read_or_write

## AXI3 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the read_or_write field of the tr_id transaction.
get_read_or_write(read_or_write, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the read_or_write field of the tr_id transaction.
get_read_or_write(read_or_write, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_gen_write_strobes()

This nonblocking procedure sets the *gen_write_strobes* field for a write transaction that is uniquely identified by the *transaction_id* field previously created by the *create_write_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_gen_write_strobes
(
   gen_write_strobes: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| gen_write_strobes | Correction of write strobes for invalid byte lanes:<br>0 = *write_strobes* passed through to protocol signals.<br>1 = *write_strobes* auto-corrected for invalid byte lanes (default). |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Disable the auto correction of the write strobes for the
-- tr_id transaction.
set_gen_write_strobes(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Disable the auto correction of the write strobes for the
-- tr_id transaction.
set_gen_write_strobes(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_gen_write_strobes()

This nonblocking procedure gets the *gen_write_strobes* field for a write transaction that is uniquely identified by the *transaction_id* field previously created by the *create_write_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_gen_write_strobes
(
   gen_write_strobes: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| gen_write_strobes | Correct write strobes flag:<br><br>0 = write_strobes passed through to protocol signals.<br>1 = write_strobes auto-corrected for invalid byte lanes. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br><br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** gen_write_strobes

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the auto correction write strobes flag of the tr_id transaction.
get_gen_write_strobes(write_strobes_flag, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the auto correction write strobes flag of the tr_id transaction.
get_gen_write_strobes(write_strobes_flag, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_operation_mode()

This nonblocking procedure sets the *operation_mode* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_operation_mode
(
   operation_mode: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| operation_mode | Operation mode:<br><br>**_TRANSACTION_NON_BLOCKING;<br>**_TRANSACTION_BLOCKING (default); |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br><br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the operation mode field to nonblocking for tr_id transaction.
set_operation_mode(AXI_TRANSACTION_NON_BLOCKING, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the operation mode field to nonblocking for tr_id transaction.
set_operation_mode(AXI4_TRANSACTION_NON_BLOCKING, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# get_operation_mode()

This nonblocking procedure gets the *operation_mode* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_operation_mode
(
   operation_mode: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| operation_mode | Operation mode:<br><br>**_TRANSACTION_NON_BLOCKING;<br>**_TRANSACTION_BLOCKING; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br><br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** operation_mode

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the operation mode field of the tr_id transaction.
get_operation_mode(operation_mode, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the operation mode field of the tr_id transaction.
get_operation_mode(operation_mode, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_delay_mode()

This AXI3 nonblocking procedure sets the *delay_mode* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
set_delay_mode
(
   delay_mode: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in axi_path_t; --optional
   signal tr_if : inout axi_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| delay_mode | Delay mode:<br><br>AXI_VALID2READY (default);<br>AXI_TRANS2READY; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br><br>AXI_PATH_0<br>AXI_PATH_1<br>AXI_PATH_2<br>AXI_PATH_3<br>AXI_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the delay mode of the *VALID to *READY handshake for the
-- tr_id transaction.
set_delay_mode(AXI_VALID2READY, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 BFM

**Note**

This procedure is not supported in the AXI4 BFM API.

# get_delay_mode()

This AXI3 nonblocking procedure gets the *delay_mode* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
get_delay_mode
(
   delay_mode: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in axi_path_t; --optional
   signal tr_if : inout axi_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| delay_mode | Delay mode:<br><br>AXI_VALID2READY;<br>AXI_TRANS2READY; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br><br>AXI_PATH_0<br>AXI_PATH_1<br>AXI_PATH_2<br>AXI_PATH_3<br>AXI_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

delay_mode

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the delay mode of the *VALID to *READY handshake of the
-- tr_id transaction.
get_delay_mode(delay_mode, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 BFM

**Note**

This procedure is not supported in the AXI4 BFM API.

# set_write_data_mode()

This nonblocking procedure sets the *write_data_mode* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_write_data_mode
(
   write_data_mode: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| write_data_mode | Write data mode:<br>**_DATA_AFTER_ADDRESS (default);<br>**_DATA_WITH_ADDRESS; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the write data mode field of the address and data phases for the
-- tr_id transaction
set_write_data_mode(AXI_DATA_WITH_ADDRESS, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the write data mode field of the address and data phases for the
-- tr_id transaction
set_write_data_mode(AXI4_DATA_WITH_ADDRESS, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# get_write_data_mode()

This nonblocking procedure gets the *write_data_mode* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_write_data_mode
(
   write_data_mode: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| write_data_mode | Write data mode:<br>**_DATA_AFTER_ADDRESS;<br>**_DATA_WITH_ADDRESS; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** write_data_mode

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the write data mode field of the tr_id transaction
get_write_data_mode(write_data_mode, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the write data mode field of the tr_id transaction
get_write_data_mode(write_data_mode, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_address_valid_delay()

This nonblocking procedure sets the *address_valid_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_address_valid_delay
(
   address_valid_delay: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| address_valid_delay | Address channel *ARVALID/AWVALID* delay measured in *ACLK* cycles for this transaction. Default: 0. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the address channel *VALID delay to 3 clock cycles
-- for the tr_id transaction.
set_address_valid_delay(3, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the address channel *VALID delay to 3 clock cycles
-- for the tr_id transaction.
set_address_valid_delay(3, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_address_valid_delay()

This nonblocking procedure gets the *address_valid_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_address_valid_delay
(
   address_valid_delay: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| address_valid_delay | Address channel *ARVALID/AWVALID* delay measured in *ACLK* cycles for this transaction. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** address_valid_delay

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the write address channel AWVALID delay of the tr_id transaction.
get_address_valid_delay(address_valid_delay, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the write address channel AWVALID delay of the tr_id transaction.
get_address_valid_delay(address_valid_delay, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_address_ready_delay()

This AXI3 nonblocking procedure sets the *address_ready_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
set_address_ready_delay
(
   address_ready_delay: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in _path_t; --optional
   signal tr_if : inout _vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| address_ready_delay | Address channel *A*READY* delay measured in *ACLK* cycles for this transaction. Default: 0. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI_PATH_0<br>AXI_PATH_1<br>AXI_PATH_2<br>AXI_PATH_3<br>AXI_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a master test program.

# get_address_ready_delay()

This nonblocking procedure gets the *address_ready_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_address_ready_delay
(
   address_ready_delay: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| address_ready_delay | Address channel *A*READY* delay measured in *ACLK* cycles for this transaction. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

address_ready_delay

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the address channel *READY delay of the tr_id transaction.
get_address_ready_delay(address_ready_delay, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the address channel *READY delay of the tr_id transaction.
get_address_ready_delay(address_ready_delay, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_data_valid_delay()

This nonblocking procedure sets the *data_valid_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_write_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_data_valid_delay
(
   data_valid_delay: in integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| data_valid_delay | Write data channel *WVALID* delay measured in *ACLK* cycles for this transaction. Default: 0. |
| index | (Optional) Array element index number for data_valid_delay. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the write channel WVALID delay to 3 ACLK cycles for the first data
-- phase (beat) of the tr_id transaction.
set_data_valid_delay(3, 0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the write channel WVALID delay to 2 ACLK cycles for the second data
-- phase (beat) of the tr_id transaction.
set_data_valid_delay(2, 1, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the write channel WVALID delay to 3 ACLK cycles for the first data
-- phase (beat) of the tr_id transaction.
set_data_valid_delay(3, 0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the write channel WVALID delay to 2 ACLK cycles for the second data
-- phase (beat) of the tr_id transaction.
set_data_valid_delay(2, 1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_data_valid_delay()

This nonblocking procedure gets the *data_valid_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_data_valid_delay
(
   data_valid_delay: out integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| data_valid_delay | Data channel array to store **VALID* delays measured in *ACLK* cycles for this transaction. |
| index | (Optional) Array element index number for data_valid_delay. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

data_valid_delay

## AXI3 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the read channel RVALID delay for the first data
-- phase (beat) of the tr_id transaction.
get_data_valid_delay(data_valid_delay, 0, tr_id, bfm_index,
axi_tr_if_0(bfm_index));

-- Get the read channel RVALID delay for the second data
-- phase (beat) of the tr_id transaction.
get_data_valid_delay(data_valid_delay, 1, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the read channel RVALID delay for the first data
-- phase (beat) of the tr_id transaction.
get_data_valid_delay(data_valid_delay, 0, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));

-- Get the read channel RVALID delay for the second data
-- phase (beat) of the tr_id transaction.
get_data_valid_delay(data_valid_delay, 1, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_data_ready_delay()

This AXI3 nonblocking procedure sets the *data_ready_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by *create_read_transaction()*.

**Prototype**

```
set_data_ready_delay
(
   data_ready_delay: in integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in axi_path_t; --optional
   signal tr_if : inout axi_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| data_ready_delay | Read data channel *RREADY* delay measured in *ACLK* cycles for this transaction. Default: 0. |
| index | (Optional) Array element index number for data_ready_delay. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI_PATH_0<br>AXI_PATH_1<br>AXI_PATH_2<br>AXI_PATH_3<br>AXI_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));
-- Set the read data channel RREADY delay to 3 ACLK cycles for the first
-- dataphase (beat) of the tr_id transaction.
set_data_ready_delay(3, 0, tr_id, bfm_index, axi_tr_if_0(bfm_index));
-- Set the read data channel RREADY delay to 2 ACLK cycles for the second
-- data phase (beat) of the tr_id transaction.
set_data_ready_delay(2, 1, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 BFM

**Note**

This procedure is not supported in the AXI4 BFM API.

# get_data_ready_delay()

This nonblocking procedure gets the *data_ready_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_data_ready_delay
(
   data_ready_delay: out integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| data_ready_delay | Read data channel *RREADY* delay measured in *ACLK* cycles for this transaction. |
| index | (Optional) Array element index number for data_ready_delay. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

data_ready_delay

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Get the write data channel WREADY delay the first
-- dataphase (beat) of the tr_id transaction.
get_data_ready_delay(data_ready_delay, 0, tr_id, bfm_index,
axi_tr_if_0(bfm_index));

-- Get the write data channel WREADY delay for the second
-- data phase (beat) of the tr_id transaction.
get_data_ready_delay(data_ready_delay, 1, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Get the write data channel WREADY delay the first
-- dataphase (beat) of the tr_id transaction.
get_data_ready_delay(data_ready_delay, 0, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));

-- Get the write data channel WREADY delay for the second
-- data phase (beat) of the tr_id transaction.
get_data_ready_delay(data_ready_delay, 1, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_write_response_valid_delay()

This nonblocking procedure sets the *write_response_valid_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_write_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_write_response_valid_delay
(
   write_response_valid_delay: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| write_response_valid_delay | Write data channel *BVALID* delay measured in *ACLK* cycles for this transaction. Default: 0. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a master test program.

# get_write_response_valid_delay()

This nonblocking procedure gets the *write_response_valid_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_write_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_write_response_valid_delay
(
   write_response_valid_delay: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| write_response_valid_delay | Write data channel *BVALID* delay measured in *ACLK* cycles for this transaction. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

| |
|---|
| write_response_valid_delay |

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the write response channel BVALID delay of the tr_id transaction.
get_write_response_valid_delay(write_response_valid_delay, tr_id,
bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the write response channel BVALID delay of the tr_id transaction.
get_write_response_valid_delay(write_response_valid_delay, tr_id,
bfm_index, axi4_tr_if_0(bfm_index));
```

# set_write_response_ready_delay()

This AXI3 nonblocking procedure sets the *write_response_ready_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_write_transaction()* procedure.

**Prototype**

```
set_write_response_ready_delay
(
   write_response_ready_delay: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in axi_path_t; --optional
   signal tr_if : inout axi_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| write_response_ready_delay | Write data channel *BREADY* delay measured in *ACLK* cycles for this transaction. Default: 0. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI_PATH_0<br>AXI_PATH_1<br>AXI_PATH_2<br>AXI_PATH_3<br>AXI_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the write response channel BREADY delay to 3 ACLK cycles
-- of the tr_id transaction.
set_write_response_ready_delay(3, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 BFM

**Note**

This procedure is not supported in the AXI4 BFM API.

# get_write_response_ready_delay()

This nonblocking procedure gets the *write_response_ready_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_write_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_write_response_ready_delay
(
   write_response_ready_delay: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| write_response_ready_delay | Write data channel *BREADY* delay measured in *ACLK* cycles for this transaction. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

| |
|---|
| write_response_ready_delay |

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the write response channel BREADY delay of the tr_id transaction.
get_write_response_ready_delay(write_resp_ready_delay, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the write response channel BREADY delay of the tr_id transaction.
get_write_response_ready_delay(write_resp_ready_delay, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_data_beat_done()

This nonblocking procedure sets the *data_beat_done* field array element for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_data_beat_done
(
   data_beat_done : in integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   ath_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| data_beat_done | Read data channel phase (beat) *done* array for this transaction. |
| index | (Optional) Array element index number for data_beat_done. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Set the read data channel data_beat_done flag for the first
-- data phase (beat) of the tr_id transaction.
set_data_beat_done(1, 0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Set the read data channel data_beat_done flag for the second
-- data phase (beat) of the tr_id transaction.
set_data_beat_done(1, 1, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Set the read data channel data_beat_done flag for the first
-- data phase (beat) of the tr_id transaction.
set_data_beat_done(1, 0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Set the read data channel data_beat_done flag for the second
-- data phase (beat) of the tr_id transaction.
set_data_beat_done(1, 1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_data_beat_done()

This nonblocking procedure gets the *data_beat_done* field array element for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_data_beat_done
(
   data_beat_done : out integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| data_beat_done | Data channel phase (beat) *done* array for this transaction |
| index | (Optional) Array element index number for data_beat_done. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

data_beat_done

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the write data channel data_beat_done flag for the first
-- data phase (beat) of the tr_id transaction.
get_data_beat_done(data_beat_done, 0, tr_id, bfm_index,
axi_tr_if_0(bfm_index));

....

-- Get the write data channel data_beat_done flag for the second
-- data phase (beat) of the tr_id transaction.
get_data_beat_done(data_beat_done, 1, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the write data channel data_beat_done flag for the first
-- data phase (beat) of the tr_id transaction.
get_data_beat_done(data_beat_done, 0, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));

....

-- Get the write data channel data_beat_done flag for the second
-- data phase (beat) of the tr_id transaction.
get_data_beat_done(data_beat_done, 1, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_transaction_done()

This nonblocking procedure sets the *transaction_done* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_transaction_done
(
   transaction_done : in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_done | Transaction *done* flag for this transaction |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Set the read transaction_done flag of the tr_id transaction.
set_transaction_done(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Set the read transaction_done flag of the tr_id transaction.
set_transaction_done(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_transaction_done()

This nonblocking procedure gets the *transaction_done* field for a transaction that is uniquely identified by the *transaction_id* field previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_transaction_done
(
   transaction_done : out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_done | Transaction *done* flag for this transaction |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** transaction_done

## AXI3 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the read transaction_done flag of the tr_id transaction.
get_transaction_done(transaction_done, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the read transaction_done flag of the tr_id transaction.
get_transaction_done(transaction_done, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# execute_transaction()

This procedure executes a master transaction that is uniquely identified by the *transaction_id* argument, previously created with either the *create_write_transaction()* or *create_read_transaction()* procedure. A transaction can be blocking (default) or nonblocking, based on the setting of the transaction *operation_mode* field.

The results of *execute_transaction()* for write transactions varies based on how write transaction fields are set. If the transaction *gen_write_strobes* field is set, *execute_transaction ()* automatically corrects any previously set *write_strobes* field array elements. However, if the *gen_write_strobes* field is not set, then any previously assigned *write_strobes* field array elements will be passed onto the *WSTRB* protocol signals, which can result in a protocol violation if not correctly set. Refer to "Automatic Correction of Byte Lane Strobes" on page 180 for more details.

If the *write_data_mode* field for a write transaction is set to **_DATA_WITH_ADDRESS,* *execute_transaction()* calls the *execute_write_addr_phase()* and *execute_write_data_burst()* procedures simultaneously; otherwise *execute_write_data_burst()* will be called after *execute_write_addr_phase()* so that the write data burst occurs after the write address phase (default). It will then call the *get_write_response_phase()* procedure to complete the write transaction.

For a read transaction, *execute_transaction ()* calls the *execute_read_addr_phase()* procedure followed by the *get_read_data_burst()* procedure to complete the read transaction.

**Prototype**

```
-- * = axi | axi4
-- ** = AXI | AXI4
procedure execute_transaction
(
   transaction_id : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the ID to 1 for this transaction
set_id(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Execute the tr_id transaction.
execute_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the ID to 1 for this transaction
set_id(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Execute the tr_id transaction.
execute_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# execute_write_addr_phase()

This procedure executes a master write address phase uniquely identified by the *transaction_id* argument previously created by the *create_write_transaction()* procedure. This phase can be blocking (default) or nonblocking, defined by the transaction record *operation_mode* field.

It sets the *AWVALID* protocol signal at the appropriate time defined by the transaction record *address_valid_delay* field.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure execute_write_addr_phase
(
   transaction_id  : in integer;
   bfm_id          : in integer;
   path_id          : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the ID to 1 for this transaction
set_id(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Execute the write address phase for the tr_id transaction.
execute_write_addr_phase(tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the ID to 1 for this transaction
set_id(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Execute the write address phase for the tr_id transaction.
execute_write_addr_phase(tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# execute_read_addr_phase()

This procedure executes a master read address phase uniquely identified by the *transaction_id* argument previously created by the *create_read_transaction()* procedure. This phase can be blocking (default) or nonblocking, defined by the transaction record *operation_mode* field.

It sets the *ARVALID* protocol signal at the appropriate time defined by the transaction record *address_valid_delay* field.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure execute_read_addr_phase
(
   transaction_id  : in integer;
   bfm_id          : in integer;
   path_id          : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the ID to 1 for this transaction
set_id(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Execute the read address phase for the tr_id transaction.
execute_read_addr_phase(tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the ID to 1 for this transaction
set_id(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Execute the read address phase for the tr_id transaction.
execute_read_addr_phase(tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# execute_write_data_burst()

This procedure executes a write data burst that is uniquely identified by the *transaction_id* argument previously created by the *create_write_transaction()* procedure. This burst can be blocking (default) or nonblocking, defined by the transaction record *operation_mode* field.

If the transaction record *gen_write_strobes* field is set, it will automatically correct any previously set *write_strobes* field array elements. If the *gen_write_strobes* field is not set then any previously assigned *write_strobes* field array elements will be passed through onto the *WSTRB* protocol signals, which can result in a protocol violation if not correctly set. Refer to "Automatic Correction of Byte Lane Strobes" on page 180 for more details.

It calls the *execute_write_data_phase()* procedure for each beat of the data burst, with the length of the burst defined by the transaction record *burst_length* field.

**Prototype**

```
-- * = axi | axi4
-- ** = AXI | AXI4
procedure execute_write_data_burst
(
   transaction_id  : in integer;
   bfm_id          : in integer;
   path_id          : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Execute the write data burst for the tr_id transaction.
execute_write_data_burst(tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Execute the write data burst for the tr_id transaction.
execute_write_data_burst(tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# execute_write_data_phase()

This procedure executes a write data phase that is uniquely identified by the *transaction_id* argument and previously created by the *create_write_transaction()* procedure. This phase can be blocking (default) or nonblocking, defined by the transaction record *operation_mode* field.

The *execute_write_data_phase()* sets the *WVALID* protocol signal at the appropriate time defined by the transaction record field *data_valid_delay* array *index* element and sets the *data_beat_done* array *index* element to 1 when the phase completes.

**Prototype**

```
-- * = axi | axi4
-- ** = AXI | AXI4
procedure execute_write_data_phase
(
   transaction_id  : in integer;
   index : in integer; --optional
   bfm_id          : in integer;
   path_id          : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| index | (Optional) Data phase (beat) number. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Execute the write data phase for the first beat of the
-- tr_id transaction.
execute_write_data_phase(tr_id, 0, bfm_index, axi_tr_if_0(bfm_index));

-- Execute the write data phase for the second beat of the
-- tr_id transaction.
execute_write_data_phase(tr_id, 1, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Execute the write data phase for the first beat of the
-- tr_id transaction.
execute_write_data_phase(tr_id, 0, bfm_index, axi4_tr_if_0(bfm_index));

-- Execute the write data phase for the second beat of the
-- tr_id transaction.
execute_write_data_phase(tr_id, 1, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_read_data_burst()

This blocking procedure gets a read data burst uniquely identified by the *transaction_id* argument previously created by the *create_read_transaction()* procedure.

It calls the *get_read_data_phase()* procedure for each beat of the data burst, with the length of the burst defined by the transaction record *burst_length* field.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure get_read_data_burst
(
   transaction_id  : in integer;
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the read data burst for the tr_id transaction.
get_read_data_burst(tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the read data burst for the tr_id transaction.
get_read_data_burst(tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_read_data_phase()

This blocking procedure gets a read data phase that is uniquely identified by the *transaction_id* argument previously created by the *create_read_transaction()* procedure. It sets the *data_beat_done* array *index* element field to 1 when the phase completes. If this is the last phase (beat) of the burst, then it sets the *transaction_done* field to 1 to indicate the whole read transaction is complete.

**Note**

For AXI3 the *get_read_data_phase()* also sets the *RREADY* protocol signal at the appropriate time defined by the transaction record *data_ready_delay* field when the phase completes.

**Prototype**

```
-- * = axi | axi4
-- ** = AXI | AXI4
procedure get_read_data_phase
(
   transaction_id  : in integer;
   index : in integer; --optional
   bfm_id          : in integer;
   path_id          : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| index | (Optional) Data phase (beat) number. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the read data phase for the first beat of the
-- tr_id transaction.
get_read_data_phase(tr_id, 0, bfm_index, axi_tr_if_0(bfm_index));

-- Get the read data phase for the second beat of the
-- tr_id transaction.
get_read_data_phase(tr_id, 1, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a read transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_read_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the read data phase for the first beat of the
-- tr_id transaction.
get_read_data_phase(tr_id, 0, bfm_index, axi4_tr_if_0(bfm_index));

-- Get the read data phase for the second beat of the
-- tr_id transaction.
get_read_data_phase(tr_id, 1, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_write_response_phase()

This blocking procedure gets a write response phase that is uniquely identified by the *transaction_id* argument previously created by the *create_write_transaction()* procedure. It sets the *transaction_done* field to 1 when the transaction completes to indicate the whole transaction is complete

**Note**

For AXI3 the *get_write_response_phase()* also sets the *BREADY* protocol signal at the appropriate time defined by the transaction record *write_response_ready_delay* field when the phase completes.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure get_write_response_phase
(
   transaction_id  : in integer;
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the write response phase for the tr_id transaction.
get_write_response_phase(tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the write response phase for the tr_id transaction.
get_write_response_phase(tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_read_addr_ready()

This blocking AXI4 procedure returns the value of the read address channel *ARREADY* signal using the *ready* argument. It will block for one *ACLK* period.

**Prototype**

```
procedure get_read_addr_ready
(
   ready : out integer;
   bfm_id          : in integer;
   path_id         : in axi4_adv_path_t; --optional
   signal tr_if    : inout axi4_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| ready | The value of the A*RREADY* signal. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI4_PATH_0<br>AXI4_PATH_1<br>AXI4_PATH_2<br>AXI4_PATH_3<br>AXI4_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** ready

## AXI3 BFM

**Note**

The *get_read_addr_ready()* procedure is not available in the AXI3 BFM.

## AXI4 Example

```
// Get the ARREADY signal value
bfm.get_read_addr_ready(ready, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_read_data_cycle()

This blocking AXI4 procedure waits until the read data channel *RVALID* signal has been asserted.

**Prototype**

```
procedure get_read_data_cycle
(
   bfm_id          : in integer;
   path_id         : in axi4_adv_path_t; --optional
   signal tr_if    : inout axi4_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI4_PATH_0<br>AXI4_PATH_1<br>AXI4_PATH_2<br>AXI4_PATH_3<br>AXI4_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 BFM

**Note**

The *get_read_data_cycle()* procedure is not available in the AXI3 BFM.

## AXI4 Example

```
// Wait for the RVALID signal to be asserted.
bfm.get_read_data_cycle(bfm_index, axi4_tr_if_0(bfm_index));
```

# execute_read_data_ready()

This AXI4 procedure executes a read data ready by placing the *ready* argument value onto the *RREADY* signal. It will block (default) for one *ACLK* period.

**Prototype**

```
procedure execute_read_data_ready
(
   ready : in integer
   non_blocking_mode : in integer; --optional
   bfm_id          : in integer;
   path_id          : in axi4_path_t; --optional
   signal tr_if    : inout axi4_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| ready | The value to be placed onto the *RREADY* signal |
| non_blocking_mode | (Optional) Nonblocking mode:<br>0 = Nonblocking<br>1 = Blocking (default) |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br><br>AXI4_PATH_0<br>AXI4_PATH_1<br>AXI4_PATH_2<br>AXI4_PATH_3<br>AXI4_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 BFM

**Note**

The *execute_read_data_ready()* task is not available in the AXI3 BFM. Use the *get_read_data_phase()* task along with the transaction record *data_ready_delay* field.

## AXI4 Example

```
-- Set the RREADY signal to 1 and block for 1 ACLK cycle
execute_read_data_ready(1, 1, index, AXI4_PATH_6, axi4_tr_if_6(index));
```

# get_write_addr_ready()

This blocking AXI4 procedure returns the value of the write address channel *AWREADY* signal using the *ready* argument. It will block for one *ACLK* period.

**Prototype**

```
procedure get_write_addr_ready
(
   ready : out integer;
   bfm_id          : in integer;
   path_id         : in axi4_adv_path_t; --optional
   signal tr_if    : inout axi4_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| ready | The value of the A*WREADY* signal. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI4_PATH_0<br>AXI4_PATH_1<br>AXI4_PATH_2<br>AXI4_PATH_3<br>AXI4_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** ready

## AXI3 BFM

**Note**

The *get_write_addr_ready()* procedure is not available in the AXI3 BFM.

## AXI4 Example

```
// Get the AWREADY signal value
bfm.get_write_addr_ready(ready, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_write_data_ready()

This blocking AXI4 procedure returns the value of the write data channel *WREADY* signal using the *ready* argument. It will block for one *ACLK* period.

**Prototype**

```
procedure get_write_data_ready
(
   ready : out integer;
   bfm_id          : in integer;
   path_id         : in axi4_adv_path_t; --optional
   signal tr_if    : inout axi4_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| ready | The value of the *WREADY* signal. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI4_PATH_0<br>AXI4_PATH_1<br>AXI4_PATH_2<br>AXI4_PATH_3<br>AXI4_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** ready

## AXI3 BFM

**Note**

The *get_write_data_ready()* procedure is not available in the AXI3 BFM.

## AXI4 Example

```
// Get the WREADY signal value
bfm.get_write_data_ready(ready, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_write_response_cycle()

This blocking AXI4 procedure waits until the write response channel *BVALID* signal has been asserted.

**Prototype**

```
procedure get_write_response_cycle
(
   bfm_id          : in integer;
   path_id         : in axi4_adv_path_t; --optional
   signal tr_if    : inout axi4_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI4_PATH_0<br>AXI4_PATH_1<br>AXI4_PATH_2<br>AXI4_PATH_3<br>AXI4_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 BFM

**Note**

The *get_write_response_cycle()* procedure is not available in the AXI3 BFM.

## AXI4 Example

```
// Wait for the BVALID signal to be asserted.
bfm.get_write_response_cycle(bfm_index, axi4_tr_if_0(bfm_index));
```

# execute_write_resp_ready()

This AXI4 procedure executes a write response ready by placing the *ready* argument value onto the *BREADY* signal. It will block for one *ACLK* period.

**Prototype**

```
procedure execute_write_resp_ready
(
   ready : in integer;
   non_blocking_mode : in integer; --optional
   bfm_id          : in integer;
   path_id          : in axi4_path_t; --optional
   signal tr_if    : inout axi4_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| ready | The value to be placed onto the *BREADY* signal |
| non_blocking_mode | (Optional) Nonblocking mode:<br>0 = Nonblocking<br>1 = Blocking (default) |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI4_PATH_0<br>AXI4_PATH_1<br>AXI4_PATH_2<br>AXI4_PATH_3<br>AXI4_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 BFM

**Note**

The *execute_write_resp_ready()* task is not available in the AXI3 BFM. Use the *get_write_response_phase()* task along with the transaction record *write_response_ready_delay* field.

## AXI4 Example

```
-- Set the BREADY signal to 1 and block for 1 ACLK cycle
execute_write_resp_ready(1, 1, index, AXI4_PATH_5, axi4_tr_if_5(index));
```

# push_transaction_id()

This nonblocking procedure pushes a transaction ID into the back of a queue. The transaction is uniquely identified by the *transaction_id* argument previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure. The queue is identified by the *queue_id* argument.

**Prototype**

```
-- * = axi | axi4
-- ** = AXI | AXI4
procedure push_transaction_id
(
   transaction_id  : in integer;
   queue_id  : in integer;
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

transaction_id — Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

queue_id — Queue identifier:

- **_QUEUE_ID_0
- **_QUEUE_ID_1
- **_QUEUE_ID_2
- **_QUEUE_ID_3
- **_QUEUE_ID_4

Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

path_id — (Optional) Parallel process path identifier:

- **_PATH_0
- **_PATH_1
- **_PATH_2
- **_PATH_3
- **_PATH_4

Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

tr_if — Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

**Returns**

None

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Push the transaction record into queue 1 for the tr_id transaction.
push_transaction_id(tr_id, AXI_QUEUE_ID_1, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Push the transaction record into queue 1 for the tr_id transaction.
push_transaction_id(tr_id, AXI4_QUEUE_ID_1, bfm_index,
axi4_tr_if_0(bfm_index));
```

# pop_transaction_id()

This nonblocking (unless queue is empty) procedure pops a transaction ID from the front of a queue. The transaction is uniquely identified by the *transaction_id* argument previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure. The queue is identified by the *queue_id* argument.

If the queue is empty then it will block until an entry becomes available.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure pop_transaction_id
(
   transaction_id  : in integer;
   queue_id  : in integer;
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

transaction_id — Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

queue_id — Queue identifier:

- **_QUEUE_ID_0
- **_QUEUE_ID_1
- **_QUEUE_ID_2
- **_QUEUE_ID_3
- **_QUEUE_ID_4

Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

path_id — (Optional) Parallel process path identifier:

- **_PATH_0
- **_PATH_1
- **_PATH_2
- **_PATH_3
- **_PATH_4

Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

tr_if — Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

**Returns**

None

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Pop the transaction record from queue 1 for the tr_id transaction.
pop_transaction_id(tr_id, AXI_QUEUE_ID_1, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Pop the transaction record from queue 1 for the tr_id transaction.
pop_transaction_id(tr_id, AXI4_QUEUE_ID_1, bfm_index,
axi4_tr_if_0(bfm_index));
```

# print()

This nonblocking procedure prints a transaction record that is uniquely identified by the *transaction_id* argument previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure print
(
   transaction_id  : in integer;
   print_delays : in integer; --optional
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

transaction_id — Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

print_delays — (Optional) Print delay values flag:

0 = do not print the delay values (default).
1 = print the delay values.

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

path_id — (Optional) Parallel process path identifier:

**_PATH_0
**_PATH_1
**_PATH_2
**_PATH_3
**_PATH_4

Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

tr_if — Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

**Returns**

None

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Print the transaction record (including delay values) of the
-- tr_id transaction.
print(tr_id, 1, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Print the transaction record (including delay values) of the
-- tr_id transaction.
print(tr_id, 1, bfm_index, axi4_tr_if_0(bfm_index));
```

# destruct_transaction()

This blocking procedure removes a transaction record for clean-up purposes and memory management that is uniquely identified by the *transaction_id* argument previously created by either the *create_write_transaction()* or *create_read_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure destruct_transaction
(
   transaction_id  : in integer;
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Remove the transaction record for the tr_id transaction.
destruct_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a write transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_write_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Remove the transaction record for the tr_id transaction.
destruct_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# wait_on()

This blocking task waits for an event(s) on the *ACLK* or *ARESETn* signals to occur before proceeding. An optional *count* argument waits for the number of events equal to *count*.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure wait_on
(
   phase           : in integer;
   count: in integer; --optional
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| phase | Wait for:<br>**_CLOCK_POSEDGE<br>**_CLOCK_NEGEDGE<br>**_CLOCK_ANYEDGE<br>**_CLOCK_0_TO_1<br>**_CLOCK_1_TO_0<br>**_RESET_POSEDGE<br>**_RESET_NEGEDGE<br>**_RESET_ANYEDGE<br>**_RESET_0_TO_1<br>**_RESET_1_TO_0 |
| count | (Optional) Wait for a number of events to occur set by *count*. (default = 1) |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
wait_on(AXI_RESET_POSEDGE, bfm_index, axi_tr_if_0(bfm_index));
wait_on(AXI_CLOCK_POSEDGE, 10, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
wait_on(AXI4_RESET_POSEDGE, bfm_index, axi4_tr_if_0(bfm_index));
wait_on(AXI4_CLOCK_POSEDGE, 10, bfm_index, axi4_tr_if_0(bfm_index));
```

# Chapter 9
# VHDL AXI3 and AXI4 Slave BFMs

This chapter provides information about the VHDL AXI3 and AXI4 slave BFMs. Each BFM has an API that contains procedures to configure the BFM and to access the Transaction Record during the lifetime of the transaction.

**Note**

Due to AXI3 protocol specification changes, for some BFM tasks, you reference the AXI3 BFM by specifying AXI instead of AXI3.

## Slave BFM Protocol Support

The AXI3 Slave BFM implements the AMBA AXI3 protocol with restrictions detailed in "Protocol Restrictions" on page 1. In addition to the standard protocol it supports user sideband signals *AWUSER* and *ARUSER*.

The AXI4 slave BFM supports the AMBA AXI4 protocol with restrictions detailed in "Protocol Restrictions" on page 1.

## Slave Timing and Events

For detailed timing diagrams of the protocol bus activity refer to the relevant AMBA AXI Protocol Specification chapter, which you can use to reference details of the following slave BFM API timing and events.

The specification does not define any timescale or clock period with signal events sampled and driven at rising *ACLK* edges. Therefore, the slave BFM does not contain any timescale, timeunit, or timeprecision declarations with the signal setup and hold times specified in units of simulator time-steps.

# Slave BFM Configuration

The slave BFM supports the full range of signals defined for the AMBA AXI protocol specification. The BFMs have parameters that can be used to configure the widths of the address, data and ID signals and transaction fields to configure timeout factors, slave exclusive support, setup and hold times, etc.

The address, data and ID signals widths can be changed from their default settings by assigning them with new values, usually performed in the top-level module of the testbench. These new values are then passed into the slave BFM via a parameter port list of the slave BFM component.

The following table lists the parameter names for the address, data and ID signals and their default values.

**Table 9-1. Slave BFM Signal Width Parameters**

| Signal Width Parameter | Description |
|---|---|
| **_ADDRESS_WIDTH | Address signal width in bits. This applies to the *ARADDR* and *AWADDR* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 64. |
| **_RDATA_WIDTH | Read data signal width in bits. This applies to the *RDATA* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 1024. |
| **_WDATA_WIDTH | Write data signal width in bits. This applies to the *WDATA* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 1024. |
| **_ID_WIDTH | ID signal width in bits. This applies to the *RID* and *WID* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 18. |
| AXI4_USER_WIDTH | (AXI4) User data signal width in bits. This applies to the *ARUSER*, *AWUSER*, *RUSER*, *WUSER* and *BUSER* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 8. |
| AXI4_REGION_MAP_SIZE | (AXI4) Region signal width in bits. This applies to the ARREGION and AWREGION signals. Refer to the AMBA AXI Protocol specification for more details. Default: 16. |

A slave BFM has configuration fields that you can set via the *set_config()* function to configure timeout factors, slave exclusive support, setup and hold times, etc. You can also get the value of a configuration field via the *get_config()* procedures. The full list of configuration fields is described in the Table 9-2.

**Table 9-2. Slave BFM Configuration**

| Configuration Field | Description |
|---|---|
| **Timing Variables** | |
| **_CONFIG_SETUP_TIME | The setup-time prior to the active edge of *ACLK*, in units of simulator time-steps for all signals.[1] Default: 0. |
| **_CONFIG_HOLD_TIME | The hold-time after the active edge of ACLK, in units of simulator time-steps for all signals.[1] Default: 0. |
| AXI_CONFIG_MAX_TRANSACTION_TIME_FACTOR | The maximum timeout duration for a read/write transaction in clock cycles. Default: 100000. |
| AXI_CONFIG_TIMEOUT_MAX_DATA_TRANSFER | (AXI3) The maximum number of write data beats that the AXI3 BFM can generate as part of write data burst of write transfer. Default: 1024. |
| **_CONFIG_BURST_TIMEOUT_ FACTOR | The maximum delay between the individual phases of a read/write transaction in clock cycles. Default: 10000. |
| AXI4_CONFIG_MAX_LATENCY_AWVALID_ ASSERTION_TO_AWREADY | (AXI4) The maximum timeout duration from the assertion of *AWVALID* to the assertion of *AWREADY* in clock periods (default 10000). |
| AXI4_CONFIG_MAX_LATENCY_ARVALID_ ASSERTION_TO_RREADY | (AXI4) The maximum timeout duration from the assertion of *ARVALID* to the assertion of *ARREADY* in clock periods (default 10000). |
| AXI4_CONFIG_MAX_LATENCY_RVALID_ ASSERTION_TO_RREADY | (AXI4) The maximum timeout duration from the assertion of *RVALID* to the assertion of *RREADY* in clock periods (default 10000). |
| AXI4_CONFIG_MAX_LATENCY_BVALID_ ASSERTION_TO_BREADY | (AXI4) The maximum timeout duration from the assertion of *BVALID* to the assertion of *BREADY* in clock periods (default 10000). |
| **Master Attributes** | |
| AXI_CONFIG_WRITE_CTRL_TO_DATA_MINTIME | (AXI3) The minimum delay from the start of a write control (address) phase to the start of a write data phase in clock cycles. Default: 1. |
| AXI_CONFIG_MASTER_WRITE_DELAY | (AXI3) The master BFM applies the AXI_CONFIG_WRITE_CTRL_TO_ DATA_MINTIME value set.<br>0 = true (default)<br>1 = false |

**Table 9-2. Slave BFM Configuration**

| Configuration Field | Description |
|---|---|
| **Timing Variables** | |
| AXI_CONFIG_MASTER_DEFAULT_UNDER_RESET | (AXI3) The master BFM drives the *ARVALID*, *AWVALID* and *WVALID* signals low during reset:<br>0 = false (default)<br>1 = true |
| AXI4_CONFIG_ENABLE_QOS | (AXI4) The master participates in the Quality-of-Service scheme. If a master does not participate, the *AWQOS/ARQOS* value used in write/read transactions must be b0000. |
| **Slave Attributes** | |
| **_CONFIG_SUPPORT_EXCLUSIVE_ACCESS | Configures the support for an exclusive slave. If enabled the BFM will expect an EXOKAY response to a successful exclusive transaction. If disabled the BFM will expect an OKAY response to an exclusive transaction. Refer to the AMBA AXI protocol specification for more details.<br>0 = disabled<br>1 = enabled (default) |
| AXI_CONFIG_SLAVE_DEFAULT_UNDER_RESET | (AXI3) The slave BFM drives the BVALID and RVALID signals low during reset. Refer to the AMBA AXI Protocol specification for more details.<br>0 = false (default)<br>1 = true |
| AXI4_CONFIG_SLAVE_START_ADDR | (AXI4) Configures the start address map for the slave. |
| AXI4_CONFIG_SLAVE_END_ADDR | (AXI4) Configures the end address map for the slave. |
| AXI4_CONFIG_READ_DATA_REORDERING_DEPTH | (AXI4) The slave read reordering depth. Refer to the AMBA AXI Protocol specification for more details. Default: 1. |
| **Error Detection** | |
| **_CONFIG_ENABLE_ALL_ASSERTIONS | Global enable/disable of all assertion checks in the BFM.<br>0 = disabled<br>1 = enabled (default) |

[1.] Refer to Slave Timing and Events for details of simulator time-steps.

# Slave Assertions

The slave BFM performs protocol error checking via built-in assertions.

**Note**
The built-in BFM assertions are independent of programming language and simulator.

## AXI3 Assertion Configuration

By default all built-in assertions are enabled in the slave BFM. To globally disable them in the slave BFM, use the *set_config()* command as the following example illustrates.

```
set_config(AXI_CONFIG_ENABLE_ALL_ASSERTIONS,0,bfm_index,
axi_tr_if_0(bfm_index));
```

Alternatively, you can disable individual built-in assertions by using a sequence of *get_config()* and *set_config()* commands on the respective assertion. For example, to disable assertion checking for the *AWLOCK* signal changing between the *AWVALID* and *AWREADY* handshake signals, use the following sequence of commands:

```
-- Define a local bit vector to hold the value of the assertion bit vector
variable config_assert_bitvector : std_logic_vector(AXI_MAX_BIT_SIZE-1
downto 0);

-- Get the current value of the assertion bit vector
get_config(AXI_CONFIG_ENABLE_ASSERTION, config_assert_bitvector,
bfm_index, axi_tr_if_0(bfm_index));

-- Assign the AXI_LOCK_CHANGED_BEFORE_AWREADY assertion bit to 0
config_assert_bitvector(AXI_LOCK_CHANGED_BEFORE_AWREADY) := '0';

-- Set the new value of the assertion bit vector
set_config(AXI_CONFIG_ENABLE_ASSERTION, config_assert_bitvector,
bfm_index, axi_tr_if_0(bfm_index));
```

**Note**
Do not confuse the *AXI_CONFIG_ENABLE_ASSERTION* bit vector with the *AXI_CONFIG_ENABLE_ALL_ASSERTIONS* global enable/disable.

To re-enable the *AXI_LOCK_CHANGED_BEFORE_AWREADY* assertion, following the above code sequence, assign the assertion in the *AXI_CONFIG_ENABLE_ASSERTION* bit vector to 1.

For a complete listing of assertions. refer to "AXI3 Assertions" on page 641.

## AXI4 Assertion Configuration

By default all built-in assertions are enabled in the slave BFM. To globally disable them in the slave BFM, use the *set_config()* command as the following example illustrates.

```
set_config(AXI4_CONFIG_ENABLE_ALL_ASSERTIONS,0,bfm_index,
axi4_tr_if_0(bfm_index));
```

Alternatively, you can disable individual built-in assertions by using a sequence of *get_config()* and *set_config()* commands on the respective assertion. For example, to disable assertion checking for the *AWLOCK* signal changing between the *AWVALID* and *AWREADY* handshake signals, use the following sequence of commands:

```
-- Define a local bit vector to hold the value of the assertion bit vector
variable config_assert_bitvector : std_logic_vector(AXI4_MAX_BIT_SIZE-1
downto 0);

-- Get the current value of the assertion bit vector
get_config(AXI4_CONFIG_ENABLE_ASSERTION, config_assert_bitvector,
bfm_index, axi4_tr_if_0(bfm_index));

-- Assign the AXI4_LOCK_CHANGED_BEFORE_AWREADY assertion bit to 0
config_assert_bitvector(AXI4_LOCK_CHANGED_BEFORE_AWREADY) := '0';

-- Set the new value of the assertion bit vector
set_config(AXI4_CONFIG_ENABLE_ASSERTION, config_assert_bitvector,
bfm_index, axi4_tr_if_0(bfm_index));
```

**Note**

Do not confuse the *AXI4_CONFIG_ENABLE_ASSERTION* bit vector with the *AXI4_CONFIG_ENABLE_ALL_ASSERTIONS* global enable/disable.

To re-enable the *AXI4_LOCK_CHANGED_BEFORE_AWREADY* assertion, following the above code sequence, assign the assertion in the *AXI4_CONFIG_ENABLE_ASSERTION* bit vector to 1.

For a complete listing of assertions, refer to "AXI4 Assertions" on page 654.

# VHDL Slave API

This section describes the VHDL Slave API.

# set_config()

This nonblocking procedure sets the configuration of the slave BFM.

## Prototype

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure set_config
(
 config_name    : in std_logic_vector(7 downto 0);
 config_val     : in std_logic_vector(**_MAX_BIT_SIZE-1 downto 0)|
 integer;
  bfm_id        : in integer;
  path_id       : in *_path_t; --optional
  signal tr_if  : inout *_vhd_if_struct_t
);
```

## Arguments

config_name

(AXI3) Configuration name:
- AXI_CONFIG_SETUP_TIME
- AXI_CONFIG_HOLD_TIME
- AXI_CONFIG_MAX_TRANSACTION_TIME_FACTOR
- AXI_CONFIG_TIMEOUT_MAX_DATA_TRANSFER
- AXI_CONFIG_BURST_TIMEOUT_FACTOR
- AXI_CONFIG_WRITE_CTRL_TO_DATA_MINTIME
- AXI_CONFIG_MASTER_WRITE_DELAY
- AXI_CONFIG_MASTER_DEFAULT_UNDER_RESET
- AXI_CONFIG_SLAVE_DEFAULT_UNDER_RESET
- AXI_CONFIG_ENABLE_ALL_ASSERTIONS
- AXI_CONFIG_MASTER_ERROR_POSITION
- AXI_CONFIG_SUPPORT_EXCLUSIVE_ACCESS

(AXI4) Configuration name:
- AXI4_CONFIG_SETUP_TIME
- AXI4_CONFIG_HOLD_TIME
- AXI4_CONFIG_BURST_TIMEOUT_FACTOR
- AXI4_CONFIG_ENABLE_RLAST
- AXI4_CONFIG_ENABLE_SLAVE_EXCLUSIVE
- AXI4_CONFIG_ENABLE_ALL_ASSERTIONS
- AXI4_CONFIG_ENABLE_ASSERTION
- AXI4_CONFIG_MAX_LATENCY_AWVALID_ASSERTION_TO_AWREADY
- AXI4_CONFIG_MAX_LATENCY_ARVALID_ASSERTION_TO_ARREADY
- AXI4_CONFIG_MAX_LATENCY_RVALID_ASSERTION_TO_RREADY
- AXI4_CONFIG_MAX_LATENCY_BVALID_ASSERTION_TO_BREADY
- AXI4_CONFIG_MAX_LATENCY_WVALID_ASSERTION_TO_WREADY
- AXI4_CONFIG_ENABLE_QOS
- AXI4_CONFIG_READ_DATA_REORDERING_DEPTH
- AXI4_CONFIG_SLAVE_START_ADDR
- AXI4_CONFIG_SLAVE_END_ADDR

config_val

Refer to "Slave BFM Configuration" on page 332 for description and valid values.

bfm_id

BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

| | | |
|---|---|---|
| | path_id | (Optional) Parallel process path identifier:<br><br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| | tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| **Returns** | None | |

## AXI3 Example

```
set_config(AXI_CONFIG_SUPPORT_EXCLUSIVE_ACCESS, 1, bfm_index,
      axi_tr_if_0(bfm_index));
set_config(AXI_CONFIG_BURST_TIMEOUT_FACTOR, 1000, bfm_index,
      axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
set_config(AXI4_CONFIG_SUPPORT_EXCLUSIVE_ACCESS, 1, bfm_index,
      axi4_tr_if_0(bfm_index));
set_config(AXI4_CONFIG_BURST_TIMEOUT_FACTOR, 1000, bfm_index,
      axi4_tr_if_0(bfm_index));
```

# get_config()

This nonblocking procedure gets the configuration of the slave BFM.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure get_config
(
  config_name    : in std_logic_vector(7 downto 0);
  config_val     : out std_logic_vector(**_MAX_BIT_SIZE-1 downto
  0)| integer;
  bfm_id         : in integer;
  path_id        : in *_path_t; --optional
  signal tr_if   : inout *_vhd_if_struct_t
);
```

**Arguments**

config_name — (AXI3) Configuration name:

- AXI_CONFIG_SETUP_TIME
- AXI_CONFIG_HOLD_TIME
- AXI_CONFIG_MAX_TRANSACTION_TIME_FACTOR
- AXI_CONFIG_TIMEOUT_MAX_DATA_TRANSFER
- AXI_CONFIG_BURST_TIMEOUT_FACTOR
- AXI_CONFIG_WRITE_CTRL_TO_DATA_MINTIME
- AXI_CONFIG_MASTER_WRITE_DELAY
- AXI_CONFIG_MASTER_DEFAULT_UNDER_RESET
- AXI_CONFIG_SLAVE_DEFAULT_UNDER_RESET
- AXI_CONFIG_ENABLE_ALL_ASSERTIONS
- AXI_CONFIG_MASTER_ERROR_POSITION
- AXI_CONFIG_SUPPORT_EXCLUSIVE_ACCESS

(AXI4) Configuration name:

- AXI4_CONFIG_SETUP_TIME
- AXI4_CONFIG_HOLD_TIME
- AXI4_CONFIG_BURST_TIMEOUT_FACTOR
- AXI4_CONFIG_ENABLE_RLAST
- AXI4_CONFIG_ENABLE_SLAVE_EXCLUSIVE
- AXI4_CONFIG_ENABLE_ALL_ASSERTIONS
- AXI4_CONFIG_ENABLE_ASSERTION
- AXI4_CONFIG_MAX_LATENCY_AWVALID_ASSERTION_TO_AWREADY
- AXI4_CONFIG_MAX_LATENCY_ARVALID_ASSERTION_TO_ARREADY
- AXI4_CONFIG_MAX_LATENCY_RVALID_ASSERTION_TO_RREADY
- AXI4_CONFIG_MAX_LATENCY_BVALID_ASSERTION_TO_BREADY
- AXI4_CONFIG_MAX_LATENCY_WVALID_ASSERTION_TO_WREADY
- AXI4_CONFIG_ENABLE_QOS
- AXI4_CONFIG_READ_DATA_REORDERING_DEPTH
- AXI4_CONFIG_SLAVE_START_ADDR
- AXI4_CONFIG_SLAVE_END_ADDR

config_val — Refer to "Slave BFM Configuration" on page 332 for description and valid values.

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

| | | |
|---|---|---|
| | path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| | tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| **Returns** | config_val | |

## AXI3 Example

```
get_config(AXI_CONFIG_SUPPORT_EXCLUSIVE_ACCESS, config_value, bfm_index,
     axi_tr_if_0(bfm_index));
get_config(AXI_CONFIG_BURST_TIMEOUT_FACTOR, config_value, bfm_index,
     axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
get_config(AXI4_CONFIG_SUPPORT_EXCLUSIVE_ACCESS, config_value,
     bfm_index, axi4_tr_if_0(bfm_index));
get_config(AXI4_CONFIG_BURST_TIMEOUT_FACTOR, config_value, bfm_index,
     axi4_tr_if_0(bfm_index));
```

# create_slave_transaction()

This nonblocking procedure creates a slave transaction. All transaction fields default to legal protocol values, unless previously assigned a value. It returns the *transaction_id* argument.

## Prototype

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure create_slave_transaction
(
   transaction_id  : out integer;
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

## Arguments

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187. |

## Protocol Transaction Fields

| | |
|---|---|
| addr | Start address |
| size | Burst size. Default: width of bus:<br>**_BYTES_1;<br>**_BYTES_2;<br>**_BYTES_4;<br>**_BYTES_8;<br>**_BYTES_16;<br>**_BYTES_32;<br>**_BYTES_64;<br>**_BYTES_128; |
| burst | Burst type:<br>**_FIXED;<br>**_INCR; (default)<br>**_WRAP;<br>**_BURST_RSVD; |
| lock | Burst lock:<br>**_NORMAL; (default)<br>**_EXCLUSIVE;<br>(AXI3) AXI_LOCKED;<br>(AXI3) AXI_LOCK_RSVD; |

| | |
|---|---|
| cache | (AXI3) Burst cache:<br>AXI_NONCACHE_NONBUF; (default)<br>AXI_BUF_ONLY;<br>AXI_CACHE_NOALLOC;<br>AXI_CACHE_BUF_NOALLOC;<br>AXI_CACHE_RSVD0;<br>AXI_CACHE_RSVD1;<br>AXI_CACHE_WTHROUGH_ALLOC_R_ONLY;<br>AXI_CACHE_WBACK_ALLOC_R_ONLY;<br>AXI_CACHE_RSVD2;<br>AXI_CACHE_RSVD3;<br>AXI_CACHE_WTHROUGH_ALLOC_W_ONLY;<br>AXI_CACHE_WBACK_ALLOC_W_ONLY;<br>AXI_CACHE_RSVD4;<br>AXI_CACHE_RSVD5;<br>AXI_CACHE_WTHROUGH_ALLOC_RW;<br>AXI_CACHE_WBACK_ALLOC_RW;<br><br>(AXI4) Burst cache:<br>AXI4_NONMODIFIABLE_NONBUF; (default)<br>AXI4_BUF_ONLY;<br>AXI4_CACHE_NOALLOC;<br>AXI4_CACHE_2;<br>AXI4_CACHE_3;<br>AXI4_CACHE_RSVD4;<br>AXI4_CACHE_RSVD5;<br>AXI4_CACHE_6;<br>AXI4_CACHE_7;<br>AXI4_CACHE_RSVD8;<br>AXI4_CACHE_RSVD9;<br>AXI4_CACHE_10;<br>AXI4_CACHE_11;<br>AXI4_CACHE_RSVD12;<br>AXI4_CACHE_RSVD12;<br>AXI4_CACHE_14;<br>AXI4_CACHE_15; |
| prot | Burst protection:<br>**_NORM_SEC_DATA; (default)<br>**_PRIV_SEC_DATA;<br>**_NORM_NONSEC_DATA;<br>**_PRIV_NONSEC_DATA;<br>**_NORM_SEC_INST;<br>**_PRIV_SEC_INST;<br>**_NORM_NONSEC_INST;<br>**_PRIV_NONSEC_INST; |
| id | Burst ID. |
| burst_length | (Optional) Burst length. Default: 0. |
| data_words | Data words array. |
| write_strobes | Write strobes array:<br>Each strobe 0 or 1. |
| resp | Burst response:<br>**_OKAY;<br>**_EXOKAY;<br>**_SLVERR;<br>**_DECERR; |
| region | (AXI4) Region identifier. |

| | | |
|---|---|---|
| | qos | (AXI4) Quality-of-Service identifier. |
| | addr_user | Address channel user data. |
| | data_user | (AXI4) Data channel user data. |
| | resp_user | (AXI4) Response channel user data. |
| | read_or_write | Read or write transaction flag:<br>**_TRANS_READ;<br>**_TRANS_WRITE |
| **Operational Transaction Fields** | gen_write_strobes | Correction of write strobes for invalid byte lanes:<br>0 = write_strobes passed through to protocol signals.<br>1 = write_strobes auto-corrected for invalid byte lanes (default). |
| | operation_mode | Operation mode:<br>**_TRANSACTION_NON_BLOCKING;<br>**_TRANSACTION_BLOCKING; (default) |
| | delay_mode | Delay mode:<br>AXI_VALID2READY; (default)<br>AXI_TRANS2READY; |
| | write_data_mode | Write data mode:<br>**_DATA_AFTER_ADDRESS; (default)<br>**_DATA_WITH_ADDRESS; |
| | address_valid_delay | Address channel *ARVALID/AWVALID* delay measured in *ACLK* cycles for this transaction (default = 0). |
| | data_valid_delay | Write data channel WVALID delay array measured in ACLK cycles for this transaction (default = 0 for all elements). |
| | write_response_valid_delay | Write data channel *BVALID* delay measured in *ACLK* cycles for this transaction (default = 0). |
| | address_ready_delay | Address channel *ARREADY/AWREADY* delay measured in *ACLK* cycles for this transaction (default = 0). |
| | data_ready_delay | Read data channel *RREADY* delay measured in *ACLK* cycles for this transaction (default = 0). |
| | write_response_ready_ delay | Write data channel *BREADY* delay measured in *ACLK* cycles for this transaction (default = 0). |
| | data_beat_done | Data channel phase (beat) *done* array for this transaction. |
| | transaction_done | Transaction *done* flag for this transaction |
| **Returns** | transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187. |

## AXI3 Example

```
-- Create a slave transaction
-- Returns the transaction ID (tr_id) for this created transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_3(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction
-- Returns the transaction ID (tr_id) for this created transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_3(bfm_index));
```

# set_addr()

This nonblocking procedure sets the start address *addr* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_addr
(
   addr : in std_logic_vector(**_MAX_BIT_SIZE-1 downto 0) |
   integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| addr | Start address of transaction. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a Slave Test Program.

# get_addr()

This nonblocking procedure gets the start address *addr* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the create_slave_transaction() procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_addr
(
   addr : out std_logic_vector(**_MAX_BIT_SIZE-1 downto 0) |
   integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| addr | Start address of transaction. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** addr

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the start address addr of the tr_id transaction
get_addr(addr, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the start address addr of the tr_id transaction
get_addr(addr, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_size()

This nonblocking procedure sets the burst *size* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_size
(
   size : in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| size | Burst size. Default: width of bus:<br>**_BYTES_1;<br>**_BYTES_2;<br>**_BYTES_4;<br>**_BYTES_8;<br>**_BYTES_16;<br>**_BYTES_32;<br>**_BYTES_64;<br>**_BYTES_128; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a Slave Test Program.

# get_size()

This nonblocking procedure gets the burst *size* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_size
(
   size : out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| size | Burst size:<br>**_BYTES_1;<br>**_BYTES_2;<br>**_BYTES_4;<br>**_BYTES_8;<br>**_BYTES_16;<br>**_BYTES_32;<br>**_BYTES_64;<br>**_BYTES_128; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** size

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the burst size of the tr_id transaction.
get_size (size, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the burst size of the tr_id transaction.
get_size (size, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_burst()

This nonblocking procedure sets the *burst* type field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_burst
(
   burst: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| burst | Burst type:<br>**_FIXED;<br>**_INCR (default);<br>**_WRAP;<br>**_BURST_RSVD; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a slave test program.

# get_burst()

This nonblocking procedure gets the *burst* type field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_burst
(
   burst: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| burst | Burst type:<br>**_FIXED;<br>**_INCR;<br>**_WRAP;<br>**_BURST_RSVD; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** burst

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the burst type of the tr_id transaction.
get_burst (burst, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the burst type of the tr_id transaction.
get_burst (burst, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_lock()

This nonblocking procedure sets the *lock* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_lock
(
   lock : in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| lock | Burst lock:<br>**_NORMAL (default);<br>**_EXCLUSIVE;<br>(AXI3) AXI_LOCKED;<br>(AXI3) AXI_LOCK_RSVD; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a slave test program.

# get_lock()

This nonblocking procedure gets the *lock* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_lock
(
   lock : out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| lock | Burst lock:<br>**_NORMAL;<br>**_EXCLUSIVE;<br>(AXI3) AXI_LOCKED;<br>(AXI3) AXI_LOCK_RSVD; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** lock

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the lock field of the tr_id transaction.
get_lock(lock, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the lock field of the tr_id transaction.
get_lock(lock, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_cache()

This nonblocking procedure sets the *cache* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_cache
(
   cache: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

cache

(AXI3) Burst cache:
- AXI_NONCACHE_NONBUF; (default)
- AXI_BUF_ONLY;
- AXI_CACHE_NOALLOC;
- AXI_CACHE_BUF_NOALLOC;
- AXI_CACHE_RSVD0;
- AXI_CACHE_RSVD1;
- AXI_CACHE_WTHROUGH_ALLOC_R_ONLY;
- AXI_CACHE_WBACK_ALLOC_R_ONLY;
- AXI_CACHE_RSVD2;
- AXI_CACHE_RSVD3;
- AXI_CACHE_WTHROUGH_ALLOC_W_ONLY;
- AXI_CACHE_WBACK_ALLOC_W_ONLY;
- AXI_CACHE_RSVD4;
- AXI_CACHE_RSVD5;
- AXI_CACHE_WTHROUGH_ALLOC_RW;
- AXI_CACHE_WBACK_ALLOC_RW;

(AXI4) Burst cache:
- AXI4_NONMODIFIABLE_NONBUF; (default)
- AXI4_BUF_ONLY;
- AXI4_CACHE_NOALLOC;
- AXI4_CACHE_2;
- AXI4_CACHE_3;
- AXI4_CACHE_RSVD4;
- AXI4_CACHE_RSVD5;
- AXI4_CACHE_6;
- AXI4_CACHE_7;
- AXI4_CACHE_RSVD8;
- AXI4_CACHE_RSVD9;
- AXI4_CACHE_10;
- AXI4_CACHE_11;
- AXI4_CACHE_RSVD12;
- AXI4_CACHE_RSVD12;
- AXI4_CACHE_14;
- AXI4_CACHE_15;

transaction_id — Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

| | |
|---|---|
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

**Note**

You do not normally use this procedure in a slave test program.

# get_cache()

This nonblocking procedure gets the *cache* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_cache
(
   cache: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

cache

(AXI3) Burst cache:
- AXI_NONCACHE_NONBUF; (default)
- AXI_BUF_ONLY;
- AXI_CACHE_NOALLOC;
- AXI_CACHE_BUF_NOALLOC;
- AXI_CACHE_RSVD0;
- AXI_CACHE_RSVD1;
- AXI_CACHE_WTHROUGH_ALLOC_R_ONLY;
- AXI_CACHE_WBACK_ALLOC_R_ONLY;
- AXI_CACHE_RSVD2;
- AXI_CACHE_RSVD3;
- AXI_CACHE_WTHROUGH_ALLOC_W_ONLY;
- AXI_CACHE_WBACK_ALLOC_W_ONLY;
- AXI_CACHE_RSVD4;
- AXI_CACHE_RSVD5;
- AXI_CACHE_WTHROUGH_ALLOC_RW;
- AXI_CACHE_WBACK_ALLOC_RW;

(AXI4) Burst cache:
- AXI4_NONMODIFIABLE_NONBUF; (default)
- AXI4_BUF_ONLY;
- AXI4_CACHE_NOALLOC;
- AXI4_CACHE_2;
- AXI4_CACHE_3;
- AXI4_CACHE_RSVD4;
- AXI4_CACHE_RSVD5;
- AXI4_CACHE_6;
- AXI4_CACHE_7;
- AXI4_CACHE_RSVD8;
- AXI4_CACHE_RSVD9;
- AXI4_CACHE_10;
- AXI4_CACHE_11;
- AXI4_CACHE_RSVD12;
- AXI4_CACHE_RSVD12;
- AXI4_CACHE_14;
- AXI4_CACHE_15;

transaction_id — Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

| | | |
|---|---|---|
| | path_id | (Optional) Parallel process path identifier:<br><br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| | tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| **Returns** | cache | |

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the cache field of the tr_id transaction.
get_cache(cache, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the cache field of the tr_id transaction.
get_cache(cache, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_prot()

This nonblocking procedure sets the protection *prot* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_prot
(
   prot: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| prot | Burst protection:<br>**_NORM_SEC_DATA (default);<br>**_PRIV_SEC_DATA;<br>**_NORM_NONSEC_DATA;<br>**_PRIV_NONSEC_DATA;<br>**_NORM_SEC_INST;<br>**_PRIV_SEC_INST;<br>**_NORM_NONSEC_INST;<br>**_PRIV_NONSEC_INST; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a slave test program.

# get_prot()

This nonblocking procedure gets the protection *prot* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_prot
(
   prot: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| prot | Burst protection:<br>**_NORM_SEC_DATA;<br>**_PRIV_SEC_DATA;<br>**_NORM_NONSEC_DATA;<br>**_PRIV_NONSEC_DATA;<br>**_NORM_SEC_INST;<br>**_PRIV_SEC_INST;<br>**_NORM_NONSEC_INST;<br>**_PRIV_NONSEC_INST; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** prot

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the protection field of the tr_id transaction.
get_prot(prot, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the protection field of the tr_id transaction.
get_prot(prot, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_id()

This nonblocking procedure sets the *id* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

## Prototype

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_id
(
  id: in integer;
  transaction_id  : in std_logic_vector(**_MAX_BIT_SIZE-1 downto
  0) | integer;
  bfm_id : in integer;
  path_id : in *_path_t; --optional
  signal tr_if : inout *_vhd_if_struct_t
);
```

## Arguments

| | |
|---|---|
| id | Burst ID |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

## Returns

None

**Note**

You do not normally use this procedure in a slave test program.

# get_id()

This nonblocking procedure gets the *id* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_id
(
 id: out integer;
 transaction_id  : in std_logic_vector(**_MAX_BIT_SIZE-1 downto
 0) | integer;
 bfm_id : in integer;
 path_id : in *_path_t; --optional
 signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| id | Burst ID |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the id field of the tr_id transaction.
get_id(id, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the id field of the tr_id transaction.
get_id(id, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_burst_length()

This nonblocking procedures sets the *burst_length* field for a transaction uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Note**

The *burst_length* field is the value that appears on the *AWLEN* and the *ARLEN* protocol signals. The number of data phases (beats) in a data burst is therefore *burst_length* + 1.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_burst_length
(
   burst_length : in std_logic_vector(**_MAX_BIT_SIZE-1 downto 0)
   | integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| burst_length | Burst length (default = 0). |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a slave test program.

# get_burst_length()

This nonblocking procedures gets the *burst_length* field for a transaction uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Note**

The *burst_length* field is the value that appears on the *AWLEN* and the *ARLEN* protocol signals. The number of data phases (beats) in a data burst is therefore *burst_length* + 1.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_burst_length
(
   burst_length : out std_logic_vector(**_MAX_BIT_SIZE-1 downto 0)
   | integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| burst_length | Burst length. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

burst_length

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the burst length field of the tr_id transaction.
get_burst_length(burst_length, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the burst length field of the tr_id transaction.
get_burst_length(burst_length, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_data_words()

This nonblocking procedure sets the read *data_words* field array elements for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_data_words
(
   data_words: in std_logic_vector(**_MAX_BIT_SIZE-1 downto 0) |
   integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| data_words | Data words array. |
| index | (Optional) Array element number for *data_words*. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the data_words field to 2 for the first read data phase (beat)
-- for the tr_id transaction.
set_data_words(2, 0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the data_words field to 3 for the second read data phase (beat)
-- for the tr_id transaction.
set_data_words(3, 1, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the data_words field to 2 for the first read data phase (beat)
-- for the tr_id transaction.
set_data_words(2, 0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the data_words field to 3 for the second read data phase (beat)
-- for the tr_id transaction.
set_data_words(3, 1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_data_words()

This nonblocking procedure gets a *data_words* field array element for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_data_words
(
   data_words: out std_logic_vector(**_MAX_BIT_SIZE-1 downto 0) |
   integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| data_words | Data words array. |
| index | (Optional) Array element number for *data_words*. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

data_words

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the data_words field of the first data phase (beat)
-- for the tr_id transaction.
get_data_words(data, 0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Get the data_words field of the second data phase (beat)
-- for the tr_id transaction.
get_data_words(data, 1, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the data_words field of the first data phase (beat)
-- for the tr_id transaction.
get_data_words(data, 0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Get the data_words field of the second data phase (beat)
-- for the tr_id transaction.
get_data_words(data, 1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_write_strobes()

This nonblocking procedure sets the *write_strobes* field array elements for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_write_strobes
(
   write_strobes : in std_logic_vector (**_MAX_BIT_SIZE-1 downto 0)
   | integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| write_strobes | Write strobes array. |
| index | (Optional) Array element number for *write_strobes*. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 123 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a slave test program.

# get_write_strobes()

This nonblocking procedure gets the *write_strobes* field array elements for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_write_strobes
(
   write_strobes : out std_logic_vector (**_MAX_BIT_SIZE-1 downto
   0) | integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| write_strobes | Write strobes array. |
| index | (Optional) Array element number for *write_strobes*. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

write_strobes

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Get the write_strobes field of the first data phase (beat)
-- for the tr_id transaction.
get_write_strobes(write_strobe, 0, tr_id, bfm_index,
axi_tr_if_0(bfm_index));

-- Get the write_strobes field of the second data phase (beat)
-- for the tr_id transaction.
get_write_strobes(write_strobe, 1, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Get the write_strobes field of the first data phase (beat)
-- for the tr_id transaction.
get_write_strobes(write_strobe, 0, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));

-- Get the write_strobes field of the second data phase (beat)
-- for the tr_id transaction.
get_write_strobes(write_strobe, 1, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_resp()

This nonblocking procedure sets the response *resp* field array elements for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_resp
(
   resp: in std_logic_vector (**_MAX_BIT_SIZE-1 downto 0) |
   integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| resp | Transaction response array:<br><br>**_OKAY = 0;<br>**_EXOKAY = 1;<br>**_SLVERR = 2;<br>**_DECERR = 3; |
| index | (Optional) Array element number for *resp*. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br><br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the read response to AXI_OKAY for the first data phase (beat)
-- for the tr_id transaction.
set_resp(AXI_OKAY, 0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the read response to AXI_DECERR for the second data phase (beat)
-- for the tr_id transaction.
set_resp(AXI_DECERR, 1, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the read response to AXI_OKAY for the first data phase (beat)
-- for the tr_id transaction.
set_resp(AXI4_OKAY, 0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the read response to AXI_DECERR for the second data phase (beat)
-- for the tr_id transaction.
set_resp(AXI4_DECERR, 1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_resp()

This nonblocking procedure gets a response *resp* field array element for a transaction uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4

get_resp
(
   resp: out std_logic_vector (**_MAX_BIT_SIZE-1 downto 0) |
   integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| resp | Transaction response array:<br>**_OKAY = 0;<br>**_EXOKAY = 1;<br>**_SLVERR = 2;<br>**_DECERR = 3; |
| index | (Optional) Array element number for *resp*. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

resp

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the response field of the first data phase (beat)
-- of the tr_id transaction.
get_resp(read_resp, 0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Get the response field of the second data phase (beat)
-- if the tr_id transaction.
get_resp(read_resp, 1, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the response field of the first data phase (beat)
-- of the tr_id transaction.
get_resp(read_resp, 0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Get the response field of the second data phase (beat)
-- if the tr_id transaction.
get_resp(read_resp, 1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_addr_user()

This nonblocking procedures sets the user data *addr_user* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_addr_user
(
   addr_user : in std_logic_vector(**_MAX_BIT_SIZE-1 downto 0) |
   integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| addr_user | User data in address phase. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a slave test program.

# get_addr_user()

This nonblocking procedures gets the user data *addr_user* field for a transaction uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_addr_user
(
   addr_user : out std_logic_vector(**_MAX_BIT_SIZE-1 downto 0) |
   integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| addr_user | User data in address phase. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** addr_user

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the address channel user data of the tr_id transaction.
get_addr_user(user_data, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the address channel user data of the tr_id transaction.
get_addr_user(user_data, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_read_or_write()

This procedure sets the *read_or_write* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

## Prototype

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_read_or_write
(
   read_or_write: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

## Arguments

| | |
|---|---|
| read_or_write | Read or write transaction:<br><br>**_TRANS_READ = 0<br>**_TRANS_WRITE = 1 |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br><br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

## Returns

None

**Note**

You do not normally use this procedure in a slave test program.

# get_read_or_write()

This nonblocking procedure gets the *read_or_write* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_read_or_write
(
   read_or_write: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

read_or_write — Read or write transaction:

**_TRANS_READ = 0
**_TRANS_WRITE = 1

transaction_id — Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

path_id — (Optional) Parallel process path identifier:

**_PATH_0
**_PATH_1
**_PATH_2
**_PATH_3
**_PATH_4

Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

tr_if — Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

**Returns**

read_or_write

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the read_or_write field of tr_id transaction.
get_read_or_write(read_or_write, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the read_or_write field of tr_id transaction.
get_read_or_write(read_or_write, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_gen_write_strobes()

This nonblocking procedure sets the *gen_write_strobes* field for a write transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

## Prototype

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_gen_write_strobes
(
   gen_write_strobes: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

## Arguments

| | |
|---|---|
| gen_write_strobes | Correction of write strobes for invalid byte lanes:<br>0 = *write_strobes* passed through to protocol signals.<br>1 = *write_strobes* auto-corrected for invalid byte lanes (default). |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

## Returns

None

**Note**

You do not normally use this procedure in a slave test program.

# get_gen_write_strobes()

This nonblocking procedure gets the *gen_write_strobes* field for a write transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_gen_write_strobes
(
   gen_write_strobes: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| gen_write_strobes | Correct write strobes flag:<br><br>0 = *write_strobes* passed through to protocol signals.<br>1 = *write_strobes* auto-corrected for invalid byte lanes. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br><br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** gen_write_strobes

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify the
transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the auto correction write strobes flag of the tr_id transaction.
get_gen_write_strobes(write_strobes_flag, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify the
transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the auto correction write strobes flag of the tr_id transaction.
get_gen_write_strobes(write_strobes_flag, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_operation_mode()

This nonblocking procedure sets the *operation_mode* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_operation_mode
(
   operation_mode: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| operation_mode | Operation mode:<br><br>**_TRANSACTION_NON_BLOCKING;<br>**_TRANSACTION_BLOCKING (default); |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br><br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the operation mode to nonblocking for the tr_id transaction.
set_operation_mode(AXI_TRANSACTION_NON_BLOCKING, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the operation mode to nonblocking for the tr_id transaction.
set_operation_mode(AXI4_TRANSACTION_NON_BLOCKING, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# get_operation_mode()

This nonblocking procedure gets the *operation_mode* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_operation_mode
(
   operation_mode: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| operation_mode | Operation mode:<br><br>**_TRANSACTION_NON_BLOCKING;<br>**_TRANSACTION_BLOCKING; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br><br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** operation_mode

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the operation mode of the tr_id transaction.
get_operation_mode(operation_mode, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the operation mode of the tr_id transaction.
get_operation_mode(operation_mode, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_delay_mode()

This AXI3 nonblocking procedure sets the *delay_mode* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

## Prototype

```
set_delay_mode
(
   delay_mode: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in axi_path_t; --optional
   signal tr_if : inout axi_vhd_if_struct_t
);
```

## Arguments

| | |
|---|---|
| delay_mode | Delay mode:<br><br>AXI_VALID2READY (default);<br>AXI_TRANS2READY; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br><br>AXI_PATH_0<br>AXI_PATH_1<br>AXI_PATH_2<br>AXI_PATH_3<br>AXI_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

## Returns

None

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the delay mode of the *VALID to *READY handshake for the
-- tr_id transaction.
set_delay_mode(AXI_VALID2READY, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 BFM

**Note**

This procedure is not supported in the AXI4 BFM API.

# get_delay_mode()

This AXI3 nonblocking procedure gets the *delay_mode* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
get_delay_mode
(
   delay_mode: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in axi_path_t; --optional
   signal tr_if : inout axi_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| delay_mode | Delay mode:<br><br>AXI_VALID2READY;<br>AXI_TRANS2READY; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br><br>AXI_PATH_0<br>AXI_PATH_1<br>AXI_PATH_2<br>AXI_PATH_3<br>AXI_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

delay_mode

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the delay mode of the *VALID to *READY handshake of the
-- tr_id transaction
get_delay_mode(delay_mode, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 BFM

**Note**

This procedure is not supported in the AXI4 BFM API.

# set_write_data_mode()

This nonblocking procedure sets the *write_data_mode* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_write_data_mode
(
   write_data_mode: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| write_data_mode | Write data mode:<br>**_DATA_AFTER_ADDRESS (default);<br>**_DATA_WITH_ADDRESS; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a slave test program.

# get_write_data_mode()

This nonblocking procedure gets the *write_data_mode* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_write_data_mode
(
   write_data_mode: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| write_data_mode | Write data mode:<br><br>**_DATA_AFTER_ADDRESS;<br>**_DATA_WITH_ADDRESS; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br><br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** write_data_mode

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the write data mode of the tr_id transaction
get_write_data_mode(write_data_mode, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the write data mode of the tr_id transaction
get_write_data_mode(write_data_mode, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_address_valid_delay()

This nonblocking procedure sets the *address_valid_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_address_valid_delay
(
   address_valid_delay: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| address_valid_delay | Address channel *ARVALID/AWVALID* delay measured in *ACLK* cycles for this transaction. Default: 0. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a slave test program.

# get_address_valid_delay()

This nonblocking procedure gets the *address_valid_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_address_valid_delay
(
   address_valid_delay: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| address_valid_delay | Address channel *ARVALID/AWVALID* delay in *ACLK* cycles for this transaction. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

address_valid_delay

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the address channel delay of the tr_id transaction.
get_address_valid_delay(address_valid_delay, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the address channel delay of the tr_id transaction.
get_address_valid_delay(address_valid_delay, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_address_ready_delay()

This AXI3 nonblocking procedure sets the *address_ready_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedures.

### Prototype

```
set_address_ready_delay
(
   address_ready_delay: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in axi_path_t; --optional
   signal tr_if : inout axi_vhd_if_struct_t
);
```

### Arguments

| | |
|---|---|
| address_ready_delay | Address channel *ARREADY/AWREADY* delay measured in *ACLK* cycles for this transaction. Default: 0. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI_PATH_0<br>AXI_PATH_1<br>AXI_PATH_2<br>AXI_PATH_3<br>AXI_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

### Returns

None

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Set the address channel ready delay to 3 ACLKs for the
-- tr_id transaction.
set_address_ready_delay(3, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 BFM

**Note**

This procedure is not supported in the AXI4 BFM API.

# get_address_ready_delay()

This nonblocking procedure gets the *address_ready_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_address_ready_delay
(
   address_ready_delay: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| address_ready_delay | Address channel *ARREADY*/AWREADY delay measured in *ACLK* cycles for this transaction. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** address_ready_delay

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the address channel *READY delay of the tr_id transaction.
get_address_ready_delay(address_ready_delay, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the address channel *READY delay of the tr_id transaction.
get_address_ready_delay(address_ready_delay, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_data_valid_delay()

This nonblocking procedure sets the *data_valid_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_data_valid_delay
(
   data_valid_delay: in integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| data_valid_delay | Read data channel array to hold *RVALID* delays measured in *ACLK* cycles for this transaction. Default: 0. |
| index | (Optional) Array element number for *data_valid_delay*. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_write_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the read channel RVALID delay to 3 ACLK cycles for the first data
-- phase (beat) of the tr_id transaction.
set_data_valid_delay(3, 0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the read channel RVALID delay to 2 ACLK cycles for the second data
-- phase (beat) of the tr_id transaction.
set_data_valid_delay(2, 1, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_write_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the read channel RVALID delay to 3 ACLK cycles for the first data
-- phase (beat) of the tr_id transaction.
set_data_valid_delay(3, 0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the read channel RVALID delay to 2 ACLK cycles for the second data
-- phase (beat) of the tr_id transaction.
set_data_valid_delay(2, 1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_data_valid_delay()

This nonblocking procedure sets the *data_valid_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_data_valid_delay
(
   data_valid_delay: out integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| data_valid_delay | Data channel array to hold *RVALID/WVALID* delays measured in *ACLK* cycles for this transaction. |
| index | (Optional) Array element number for *data_valid_delay*. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

data_valid_delay

## AXI3 Example

```
-- Create a slave transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....
-- Get the write channel WVALID delay for the first data
-- phase (beat) of the tr_id transaction.
get_data_valid_delay(data_valid_delay, 0, tr_id, bfm_index,
axi_tr_if_0(bfm_index));

-- Get the write channel WVALID delay for the second data
-- phase (beat) of the tr_id transaction.
get_data_valid_delay(data_valid_delay, 1, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....
-- Get the write channel WVALID delay for the first data
-- phase (beat) of the tr_id transaction.
get_data_valid_delay(data_valid_delay, 0, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));

-- Get the write channel WVALID delay for the second data
-- phase (beat) of the tr_id transaction.
get_data_valid_delay(data_valid_delay, 1, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_data_ready_delay()

This AXI3 nonblocking procedure sets the *data_ready_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by *create_slave_transaction()*.

**Prototype**

```
set_data_ready_delay
(
   data_ready_delay: in integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in axi_path_t; --optional
   signal tr_if : inout axi_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| data_ready_delay | Write data channel array to hold *WREADY* delays measured in *ACLK* cycles for this transaction. Default: 0. |
| index | (Optional) Array element number for *data_ready_delay*. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI_PATH_0<br>AXI_PATH_1<br>AXI_PATH_2<br>AXI_PATH_3<br>AXI_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));
-- Set the write data channel WREADY delay to 3 ACLK cycles for the first
-- dataphase (beat) of the tr_id transaction.
set_data_ready_delay(3, 0, tr_id, bfm_index, axi_tr_if_0(bfm_index));
-- Set the write data channel WREADY delay to 2 ACLK cycles for the second
-- data phase (beat) of the tr_id transaction.
set_data_ready_delay(2, 1, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 BFM

**Note**

This procedure is not supported in the AXI4 BFM API.

# get_data_ready_delay()

This nonblocking procedure gets the *data_ready_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_data_ready_delay
(
   data_ready_delay: out integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| data_ready_delay | Data channel array to hold *RREADY*/WREADY delay measured in *ACLK* cycles for this transaction. |
| index | (Optional) Array element number for *data_ready_delay* |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Get the read data channel RREADY delay for the first
-- data phase (beat) of the tr_id transaction.
get_data_ready_delay(data_ready_delay, 0, tr_id, bfm_index,
axi_tr_if_0(bfm_index));

-- Get the read data channel RREADY delay for the second
-- data phase (beat) of the tr_id transaction.
get_data_ready_delay(data_ready_delay, 1, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Get the read data channel RREADY delay for the first
-- data phase (beat) of the tr_id transaction.
get_data_ready_delay(data_ready_delay, 0, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));

-- Get the read data channel RREADY delay for the second
-- data phase (beat) of the tr_id transaction.
get_data_ready_delay(data_ready_delay, 1, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_write_response_valid_delay()

This nonblocking procedure sets the *write_response_valid_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
set_write_response_valid_delay
(
   write_response_valid_delay: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| write_response_valid_delay | Write data channel *BVALID* delay measured in *ACLK* cycles for this transaction. Default: 0. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the write response channel BVALID delay to 3 ACLK cycles for the
-- tr_id transaction.
set_write_response_valid_delay(3, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the write response channel BVALID delay to 3 ACLK cycles for the
-- tr_id transaction.
set_write_response_valid_delay(3, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# get_write_response_valid_delay()

This nonblocking procedure gets the *write_response_valid_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_write_response_valid_delay
(
   write_response_valid_delay: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| write_response_valid_delay | Write data channel *BVALID* delay measured in *ACLK* cycles for this transaction. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

| |
|---|
| write_response_valid_delay |

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the write response channel BVALID delay of the tr_id transaction.
get_write_response_valid_delay(write_response_valid_delay, tr_id,
bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the write response channel BVALID delay of the tr_id transaction.
get_write_response_valid_delay(write_response_valid_delay, tr_id,
bfm_index, axi4_tr_if_0(bfm_index));
```

# set_write_response_ready_delay()

This AXI3 nonblocking procedure sets the *write_response_ready_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
set_write_response_ready_delay
(
   write_response_ready_delay: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in axi_path_t; --optional
   signal tr_if : inout axi_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| write_response_ready_delay | Write data channel *BREADY* delay measured in *ACLK* cycles for this transaction. Default: 0. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI_PATH_0<br>AXI_PATH_1<br>AXI_PATH_2<br>AXI_PATH_3<br>AXI_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a slave test program.

# get_write_response_ready_delay()

This nonblocking procedure gets the *write_response_ready_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_write_response_ready_delay
(
   write_response_ready_delay: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| write_response_ready_delay | Write data channel *BREADY* delay measured in *ACLK* cycles for this transaction. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

| |
|---|
| write_response_ready_delay |

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the write response channel BREADY delay of the tr_id transaction.
get_write_response_ready_delay(write_resp_ready_delay, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the write response channel BREADY delay of the tr_id transaction.
get_write_response_ready_delay(write_resp_ready_delay, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_data_beat_done()

This nonblocking procedure sets the *data_beat_done* field array element for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_data_beat_done
(
   data_beat_done : in integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| data_beat_done | Write data channel phase (beat) *done* array for this transaction. |
| index | (Optional) Array element number for *data_beat_done*. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Set the write data channel data_beat_done flag for the first
-- data phase (beat) of the tr_id transaction.
set_data_beat_done(1, 0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Set the write data channel data_beat_done flag for the second
-- data phase (beat) of the tr_id transaction.
set_data_beat_done(1, 1, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Set the write data channel data_beat_done flag for the first
-- data phase (beat) of the tr_id transaction.
set_data_beat_done(1, 0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Set the write data channel data_beat_done flag for the second
-- data phase (beat) of the tr_id transaction.
set_data_beat_done(1, 1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_data_beat_done()

This nonblocking procedure gets the *data_beat_done* field array element for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_data_beat_done
(
   data_beat_done : out integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| data_beat_done | Data channel phase (beat) *done* array for this transaction |
| index | (Optional) Array element number for *data_beat_done*. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

data_beat_done

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....
-- Get the read data channel data_beat_done flag for the first
-- data phase (beat) of the tr_id transaction.
get_data_beat_done(data_beat_done, 0, tr_id, bfm_index,
axi_tr_if_0(bfm_index));

....
-- Get the read data channel data_beat_done flag for the second
-- data phase (beat) of the tr_id transaction.
get_data_beat_done(data_beat_done, 1, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....
-- Get the read data channel data_beat_done flag for the first
-- data phase (beat) of the tr_id transaction.
get_data_beat_done(data_beat_done, 0, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));

....
-- Get the read data channel data_beat_done flag for the second
-- data phase (beat) of the tr_id transaction.
get_data_beat_done(data_beat_done, 1, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_transaction_done()

This nonblocking procedure sets the *transaction_done* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_transaction_done
(
   transaction_done : in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_done | Transaction *done* flag for this transaction |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a slave transaction.
-- Creation returns tr_id to identify the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Set the read transaction_done flag of the tr_id transaction.
set_transaction_done(1, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction.
-- Creation returns tr_id to identify the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Set the slave transaction_done flag of the tr_id transaction.
set_transaction_done(1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_transaction_done()

This nonblocking procedure gets the *transaction_done* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_transaction_done
(
   transaction_done : out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_done | Transaction *done* flag for this transaction |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** transaction_done

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the transaction_done flag of the tr_id transaction.
get_transaction_done(transaction_done, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the transaction_done flag of the tr_id transaction.
get_transaction_done(transaction_done, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# execute_read_data_burst()

This procedure executes a read data burst that is uniquely identified by the *transaction_id* argument previously created by the *create_slave_transaction()* procedure. This burst can be blocking (default), or nonblocking, defined by the transaction record *operation_mode* field.

It calls the *execute_read_data_phase()* procedure for each beat of the data burst, with the length of the burst defined by the transaction record *burst_length* field

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure execute_read_data_burst
(
   transaction_id  : in integer;
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Execute the read data burst for the tr_id transaction.
execute_read_data_burst(tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Execute the read data burst for the tr_id transaction.
execute_read_data_burst(tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# execute_read_data_phase()

This procedure executes a read data phase that is uniquely identified by the *transaction_id* argument previously created by the *create_slave_transaction()* procedure. This phase can be blocking (default) or nonblocking, defined by the transaction record *operation_mode* field.

The *execute_read_data_phase()* sets the *RVALID* protocol signal at the appropriate time defined by the transaction record *data_valid_delay* field and sets the *data_beat_done* array *index* element field to 1 when the phase completes. If this is the last data phase (beat) of the burst, it also sets the *transaction_done* field on completion.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure execute_read_data_phase
(
   transaction_id  : in integer;
   index : in integer; --optional
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| index | (Optional) Data phase (beat) number. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....
-- Execute the read data phase for the first beat of the
-- tr_id transaction.
execute_read_data_phase(tr_id, 0, bfm_index, axi_tr_if_0(bfm_index));

-- Execute the read data phase for the second beat of the
-- tr_id transaction.
execute_read_data_phase(tr_id, 1, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....
-- Execute the read data phase for the first beat of the
-- tr_id transaction.
execute_read_data_phase(tr_id, 0, bfm_index, axi4_tr_if_0(bfm_index));

-- Execute the read data phase for the second beat of the
-- tr_id transaction.
execute_read_data_phase(tr_id, 1, bfm_index, axi4_tr_if_0(bfm_index));
```

# execute_write_response_phase()

This procedure executes a write response phase that is uniquely identified by the *transaction_id* argument previously created by the *create_slave_transaction()* procedure. This phase can be blocking (default) or nonblocking, defined by the transaction record *operation_mode* field.

It sets the *BVALID* protocol signal at the appropriate time defined by the transaction record *write_response_valid_delay* field, and sets the *data_beat_done* array *index* element field on completion. If this is the last data phase (beat) of the burst, it also sets the *transaction_done* field on completion.

**Prototype**

```
-- * = axi | axi4
-- ** = AXI | AXI4
procedure execute_write_response_phase
(
   transaction_id  : in integer;
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_2(bfm_index));

....

-- Execute the write response phase of the tr_id transaction.
execute_write_response_phase(tr_id, bfm_index, axi_tr_if_2(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_2(bfm_index));

....

-- Execute the write response phase of the tr_id transaction.
execute_write_response_phase(tr_id, bfm_index, axi4_tr_if_2(bfm_index));
```

# get_write_addr_phase()

This blocking procedure gets a write address phase uniquely identified by the *transaction_id* argument previously created by the *create_slave_transaction()* procedure.

**Note**

For AXI3 the *get_write_addr_phase()* also sets the *AWREADY* protocol signal at the appropriate time defined by the transaction record *address_ready_delay* field.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure get_write_addr_phase
(
   transaction_id  : in integer;
   bfm_id          : in integer;
   path_id         : in *_path_t; -- Optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the write address phase of the tr_id transaction.
get_write_addr_phase(tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the write address phase of the tr_id transaction.
get_write_addr_phase(tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_read_addr_phase()

This blocking procedure gets a read address phase uniquely identified by the *transaction_id* argument previously created by the *create_slave_transaction()* procedure.

**Note**

For AXI3 the *get_read_addr_phase()* also sets the *ARREADY* protocol signal at the appropriate time defined by the transaction record *address_ready_delay* field.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure get_read_addr_phase
(
   transaction_id  : in integer;
   bfm_id          : in integer;
   path_id         : in *_path_t; -- Optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the read address phase of the tr_id transaction.
get_read_addr_phase(tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the read address phase of the tr_id transaction.
get_read_addr_phase(tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_write_data_phase()

This blocking procedure gets a write data phase that is uniquely identified by the *transaction_id* argument previously created by the *create_slave_transaction()* procedure. It sets the *data_beat_done* array *index* element to 1 when the phase completes. If this is the last data phase of the burst then it returns the *last* argument set to 1.

**Note**

For AXI3 the *get_write_data_phase()* also sets the *WREADY* protocol signal at the appropriate time defined by the transaction record *data_ready_delay* array *index* element when the phase completes

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure get_write_data_phase
(
   transaction_id  : in integer;
   index : in integer; --optional
   last : out integer;
   bfm_id          : in integer;
   path_id          : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| index | (Optional) Data phase (beat) number. |
| last | Last data phase (beat) of the burst:<br>0 = data burst not complete<br>1 = data burst complete |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

last

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the write data phase for the first beat of the tr_id transaction.
get_write_data_phase(tr_id, 0, last, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the write data phase for the second beat of the tr_id transaction.
get_write_data_phase(tr_id, 1, last, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the write data phase for the first beat of the tr_id transaction.
get_write_data_phase(tr_id, 0, last, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the write data phase for the second beat of the tr_id transaction.
get_write_data_phase(tr_id, 1, last, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_write_data_burst()

This blocking procedure gets a write data burst that is uniquely identified by the *transaction_id* argument previously created by the *create_slave_transaction()* procedure.

It calls the *get_write_data_phase()* procedure for each beat of the data burst, with the length of the burst defined by the transaction record *burst_length* field.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure get_write_data_burst
(
   transaction_id  : in integer;
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the write data burst for the tr_id transaction.
get_write_data_burst(tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the write data burst for the tr_id transaction.
get_write_data_burst(tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

# get_read_addr_cycle()

This blocking AXI4 procedure waits until the read address channel *ARVALID* signal is asserted.

**Prototype**

```
procedure get_read_addr_cycle
(
   bfm_id          : in integer;
   path_id         : in axi4_adv_path_t; --optional
   signal tr_if    : inout axi4_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br><br>AXI4_PATH_0<br>AXI4_PATH_1<br>AXI4_PATH_2<br>AXI4_PATH_3<br>AXI4_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 BFM

**Note**

The *get_read_addr_cycle()* procedure is not available in the AXI3 BFM.

## AXI4 Example

```
// Wait for the ARVALID signal to be asserted.
bfm.get_read_addr_cycle(bfm_index, axi4_tr_if_0(bfm_index));
```

# execute_read_addr_ready()

This AXI4 procedure executes a read address ready by placing the *ready* argument value onto the A*RREADY* signal. It will block (default) for one *ACLK* period.

**Prototype**

```
procedure execute_read_addr_ready
(
   ready : in integer;
   bfm_id          : in integer;
   path_id         : in axi4_path_t; --optional
   signal tr_if    : inout axi4_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| non_blocking_ mode | (Optional) Nonblocking mode:<br>0 = Nonblocking<br>1 = Blocking (default) |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI4_PATH_0<br>AXI4_PATH_1<br>AXI4_PATH_2<br>AXI4_PATH_3<br>AXI4_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 BFM

**Note**

The *execute_read_addr_ready()* task is not available in the AXI3 BFM. Use the *get_read_addr_phase()* task along with the transaction record *address_ready_delay* field.

## AXI4 Example

```
-- Set the ARREADY signal to 1 and block for 1 ACLK cycle
execute_read_addr_ready(1, 1, index, AXI4_PATH_6, axi4_tr_if_6(index));
```

# get_read_data_ready()

This blocking AXI4 procedure returns the value of the read data channel *RREADY* signal using the *ready* argument. It will block for one *ACLK* period.

**Prototype**

```
procedure get_read_data_ready
(
   ready : out integer;
   bfm_id          : in integer;
   path_id         : in axi4_adv_path_t; --optional
   signal tr_if    : inout axi4_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| ready | The value of the *RREADY* signal. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI4_PATH_0<br>AXI4_PATH_1<br>AXI4_PATH_2<br>AXI4_PATH_3<br>AXI4_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** ready

## AXI3 BFM

**Note**

The *get_read_data_ready()* procedure is not available in the AXI3 BFM.

## AXI4 Example

```
// Get the RREADY signal value
bfm.get_read_data_ready(ready, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_write_addr_cycle()

This blocking AXI4 procedure waits until the write address channel *AWVALID* signal is asserted.

**Prototype**

```
procedure get_write_addr_cycle
(
   bfm_id          : in integer;
   path_id         : in axi4_adv_path_t; --optional
   signal tr_if    : inout axi4_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI4_PATH_0<br>AXI4_PATH_1<br>AXI4_PATH_2<br>AXI4_PATH_3<br>AXI4_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 BFM

**Note**

The *get_write_addr_cycle()* procedure is not available in the AXI3 BFM.

## AXI4 Example

```
// Wait for the AWVALID signal to be asserted.
bfm.get_write_addr_cycle(bfm_index, axi4_tr_if_0(bfm_index));
```

# execute_write_addr_ready()

This AXI4 procedure executes a write address ready by placing the *ready* argument value onto the *AWREADY* signal. It will block for one *ACLK* period.

**Prototype**

```
procedure execute_write_addr_ready
(
   ready : in integer;
   bfm_id          : in integer;
   path_id         : in axi4_path_t; --optional
   signal tr_if    : inout axi4_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| index | (Optional) Data phase (beat) number. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI4_PATH_0<br>AXI4_PATH_1<br>AXI4_PATH_2<br>AXI4_PATH_3<br>AXI4_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 BFM

**Note**

The *execute_write_addr_ready()* task is not available in the AXI3 BFM. Use the *get_write_addr_phase()* task along with the transaction record *address_ready_delay* field.

## AXI4 Example

```
-- Set the AWREADY signal to 1 and block for 1 ACLK cycle
execute_write_addr_ready(1, 1, index, AXI4_PATH_5, axi4_tr_if_5(index));
```

# get_write_data_cycle()

This blocking AXI4 procedure waits until the write data channel *WVALID* signal is asserted.

**Prototype**

```
procedure get_write_data_cycle
(
   bfm_id          : in integer;
   path_id         : in axi4_adv_path_t; --optional
   signal tr_if    : inout axi4_vhd_if_struct_t
);
```

**Arguments**

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

path_id — (Optional) Parallel process path identifier:

AXI4_PATH_0
AXI4_PATH_1
AXI4_PATH_2
AXI4_PATH_3
AXI4_PATH_4

Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

tr_if — Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

**Returns**

None

## AXI3 BFM

**Note**

The *get_write_data_cycle()* procedure is not available in the AXI3 BFM.

## AXI4 Example

```
// Wait for the WVALID signal to be asserted.
bfm.get_write_data_cycle(bfm_index, axi4_tr_if_0(bfm_index));
```

# execute_write_data_ready()

This AXI4 procedure executes a write data ready by placing the *ready* argument value onto the *WREADY* signal. It blocks for one *ACLK* period.

**Prototype**

```
procedure execute_write_data_ready
(
   ready : in integer;
   bfm_id          : in integer;
   path_id         : in axi4_path_t; --optional
   signal tr_if    : inout axi4_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| non_blocking_mode | (Optional) Nonblocking mode:<br>0 = Nonblocking<br>1 = Blocking (default) |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br><br>AXI4_PATH_0<br>AXI4_PATH_1<br>AXI4_PATH_2<br>AXI4_PATH_3<br>AXI4_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 BFM

**Note**

The *execute_write_data_ready()* task is not available in the AXI3 BFM. Use the *get_write_data_phase()* task along with the transaction record *address_ready_delay* field.

## AXI4 Example

```
-- Set the WREADY signal to 1 and block for 1 ACLK cycle
execute_write_data_ready(1, 1, index, AXI4_PATH_7, axi4_tr_if_7(index));
```

# get_write_resp_ready()

This blocking AXI4 procedure returns the value of the write response channel *BREADY* signal using the *ready* argument. It blocks for one *ACLK* period.

**Prototype**

```
procedure get_write_resp_ready
(
   ready : out integer;
   bfm_id          : in integer;
   path_id         : in axi4_adv_path_t; --optional
   signal tr_if    : inout axi4_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| ready | The value of the *RREADY* signal. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI4_PATH_0<br>AXI4_PATH_1<br>AXI4_PATH_2<br>AXI4_PATH_3<br>AXI4_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** ready

## AXI3 BFM

**Note**

The *get_write_resp_ready()* procedure is not available in the AXI3 BFM.

## AXI4 Example

```
// Get the BREADY signal value
bfm.get_write_resp_ready(ready, bfm_index, axi4_tr_if_0(bfm_index));
```

# push_transaction_id()

This nonblocking procedure pushes a transaction ID into the back of a queue. The transaction is uniquely identified by the *transaction_id* argument previously created by the *create_slave_transaction()* procedure. The queue is identified by the *queue_id* argument.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure push_transaction_id
(
   transaction_id  : in integer;
   queue_id  : in integer;
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| queue_id | Queue identifier:<br>**_QUEUE_ID_0<br>**_QUEUE_ID_1<br>**_QUEUE_ID_2<br>**_QUEUE_ID_3<br>**_QUEUE_ID_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Push the transaction record into queue 1 for the tr_id transaction.
push_transaction_id(tr_id, AXI_QUEUE_ID_1, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Push the transaction record into queue 1 for the tr_id transaction.
push_transaction_id(tr_id, AXI4_QUEUE_ID_1, bfm_index,
axi4_tr_if_0(bfm_index));
```

# pop_transaction_id()

This nonblocking (unless queue is empty) procedure pops a transaction ID from the front of a queue. The transaction is uniquely identified by the *transaction_id* argument previously created by the *create_slave_transaction()* procedure. The queue is identified by the *queue_id* argument.

If the queue is empty then it will block until an entry becomes available.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure pop_transaction_id
(
   transaction_id  : in integer;
   queue_id  : in integer;
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

transaction_id — Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

queue_id — Queue identifier:

- **_QUEUE_ID_0
- **_QUEUE_ID_1
- **_QUEUE_ID_2
- **_QUEUE_ID_3
- **_QUEUE_ID_4

Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

path_id — (Optional) Parallel process path identifier:

- **_PATH_0
- **_PATH_1
- **_PATH_2
- **_PATH_3
- **_PATH_4

Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

tr_if — Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

**Returns**

None

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Pop the transaction record from queue 1 for the tr_id transaction.
pop_transaction_id(tr_id, AXI_QUEUE_ID_1, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Pop the transaction record from queue 1 for the tr_id transaction.
pop_transaction_id(tr_id, AXI4_QUEUE_ID_1, bfm_index,
axi4_tr_if_0(bfm_index));
```

# print()

This nonblocking procedure prints a transaction record that is uniquely identified by the *transaction_id* argument previously created by the create_slave_transaction() procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure print
(
   transaction_id  : in integer;
   print_delays : in integer; --optional
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

transaction_id — Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

print_delays — (Optional) Print delay values flag:

0 = do not print the delay values (default).
1 = print the delay values.

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

path_id — (Optional) Parallel process path identifier:

**_PATH_0
**_PATH_1
**_PATH_2
**_PATH_3
**_PATH_4

Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

tr_if — Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

**Returns**

None

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Print the transaction record (including delay values) of the
-- tr_id transaction.
print(tr_id, 1, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Print the transaction record (including delay values) of the
-- tr_id transaction.
print(tr_id, 1, bfm_index, axi4_tr_if_0(bfm_index));
```

# destruct_transaction()

This blocking procedure removes a transaction record for clean-up purposes and memory management, uniquely identified by the *transaction_id* argument previously created by the *create_slave_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure destruct_transaction
(
   transaction_id  : in integer;
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Remove the transaction record for the tr_id transaction.
destruct_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a slave transaction. Creation returns tr_id to identify
-- the transaction.
create_slave_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Remove the transaction record for the tr_id transaction.
destruct_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# wait_on()

This blocking procedure waits for an event on the *ACLK* or *ARESETn* signals to occur before proceeding. An optional *count* argument waits for the number of events equal to *count*.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure wait_on
(
   phase           : in integer;
   count: in integer; --optional
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| phase | Wait for:<br>**_CLOCK_POSEDGE<br>**_CLOCK_NEGEDGE<br>**_CLOCK_ANYEDGE<br>**_CLOCK_0_TO_1<br>**_CLOCK_1_TO_0<br>**_RESET_POSEDGE<br>**_RESET_NEGEDGE<br>**_RESET_ANYEDGE<br>**_RESET_0_TO_1<br>**_RESET_1_TO_0 |
| count | (Optional) Wait for a number of events to occur set by *count*. (default = 1) |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
wait_on(AXI_RESET_POSEDGE, bfm_index, axi_tr_if_0(bfm_index));
wait_on(AXI_CLOCK_POSEDGE, 10, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
wait_on(AXI4_RESET_POSEDGE, bfm_index, axi4_tr_if_0(bfm_index));
wait_on(AXI4_CLOCK_POSEDGE, 10, bfm_index, axi4_tr_if_0(bfm_index));
```

# Helper Functions

AMBA AXI protocols typically provide a start address only in a transaction, with the following addresses for each byte of a data burst calculated using the size, length, and type transaction fields of the transaction. Helper functions provide you with a simple interface to set and get actual address/data values.

## get_write_addr_data()

This nonblocking procedure returns the actual address *addr* and *data* of a particular byte in a write data burst. It also returns the maximum number of bytes (*dynamic_size*) in the write data phase (beat). It is used in a slave test program as a helper procedure to store a byte of data at a particular address in the slave memory. If the corresponding *index* does not exist, then this function returns *false*, otherwise it returns *true*.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure get_write_addr_data
(
   transaction_id  : in integer;
   index           : in integer;
   byte_index      : in integer;
   dynamic_size    : out integer;
   addr            : out std_logic_vector(**_MAX_BIT_SIZE-1
   downto 0);
   data            : out std_logic_vector(7 downto 0);
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| index | Data words array element number. |
| byte_index | Data byte number in a data phase (beat) |
| dynamic_size | Number of data bytes in a data phase (beat). |
| addr | Data byte address. |
| data | Write data byte. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

| | | |
|---|---|---|
| | tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| **Returns** | dynamic_size | |
| | addr | |
| | data | |

## AXI3 Example

```
-- Wait for the write data burst to complete for the tr_id transaction.
get_write_data_burst(tr_id, bfm_index, axi_tr_if_1(bfm_index));

-- Get the burst length of the tr_id transaction.
get_burst_length(burst_length, tr_id, bfm_index, axi_tr_if_1(bfm_index));

-- Loop for the length of the data burst.
for i in  0 to burst_length loop

   -- Get the address, first data byte and byte length for the
   -- data phase (beat)
   get_write_addr_data(tr_id, i, 0, byte_length, addr, data, bfm_index,
                       axi_tr_if_1(bfm_index));

   -- Store the first data byte in the slave memory using the
   -- slave test program do_byte_write procedure
   do_byte_write(addr, data);

   -- Get the remaining bytes of the write data phase (beat)
   -- and store thenm in the slave memory.
   if byte_length > 1 then
      for j in 1 to byte_length-1 loop

         get_write_addr_data(write_trans, i, j, byte_length, addr, data,
                             index, axi_tr_if_1(index));
         do_byte_write(addr, data);
      end loop;
   end if;
end loop;
```

## AXI4 Example

```
-- Wait for the write data burst to complete for the tr_id transaction.
get_write_data_burst(tr_id, bfm_index, axi4_tr_if_1(bfm_index));

-- Get the burst length of the tr_id transaction.
get_burst_length(burst_length, tr_id, bfm_index,
      axi4_tr_if_1(bfm_index));

-- Loop for the length of the data burst.
for i in  0 to burst_length loop

   -- Get the address, first data byte and byte length for the
   -- data phase (beat)
   get_write_addr_data(tr_id, i, 0, byte_length, addr, data, bfm_index,
                       axi4_tr_if_1(bfm_index));

   -- Store the first data byte in the slave memory using the
   -- slave test program do_byte_write procedure
   do_byte_write(addr, data);

   -- Loop for the number of bytes in the write data phase (beat)
   -- given by the byte_length
   if byte_length > 1 then
      for j in 1 to byte_length-1 loop

         -- Get the remaining bytes of the write data phase (beat)
         -- and store thenm into the slave memory.
         get_write_addr_data(write_trans, i, j, byte_length, addr, data,
                             index, axi4_tr_if_1(index));
         do_byte_write(addr, data);
      end loop;
   end if;
end loop;
```

# get_read_addr()

This nonblocking procedure returns the actual address *addr* a particular byte in a read data transaction. It also returns the maximum number of bytes (*dynamic_size*) in the read data phase (beat). It is used in a slave test program as a helper procedure to return the address of a data byte in the slave memory.

## Prototype

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure get_read_addr
(
   transaction_id  : in integer;
   index           : in integer;
   byte_index      : in integer;
   dynamic_size    : out integer;
   addr            : out std_logic_vector(**_MAX_BIT_SIZE-1
   downto 0);
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

## Arguments

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| index | Data words array element number. |
| byte_index | Data byte number in a data phase (beat) |
| dynamic_size | Number of data bytes in a data phase (beat). |
| addr | Data byte address. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

## Returns

dynamic_size

addr

## AXI3 Example

```
-- Wait for the write data burst to complete for the transaction.
get_burst_length(burst_length, read_trans, index, AXI_PATH_4,
                     axi_tr_if_4(index));

-- Loop for the length of the data burst.
for i in  0 to burst_length loop

   -- Get the byte address and number of bytes in the data phase (beat).
   get_read_addr(read_trans,  i, 0, byte_length, addr, index, AXI_PATH_4,
                  axi_tr_if_4(index));

   -- Retrieve the first data byte from the slave memory using the
   -- slave test program do_byte_read procedure.
   do_byte_read(addr, data);

   -- Set the first read data byte for the read_trans transaction.
   set_read_data(read_trans, i, 0, byte_length, addr, data, index,
                    AXI_PATH_4, axi_tr_if_4(index));

   -- Loop for the number of bytes in the data phase (beat)
   -- given by the byte_length.
   if byte_length > 1 then
      for j in 1 to byte_length-1 loop

         -- Get the next read data byte address.
         get_read_addr(read_trans,  i, j, byte_length, addr, index,
                          AXI_PATH_4, axi_tr_if_4(index));

         -- Retrieve the next data byte from the slave memory using the
         -- slave test program do_byte_read procedure.
         do_byte_read(addr, data);

         -- Set the next read data byte for the read_trans transaction.
         set_read_data(read_trans, i, j, byte_length, addr, data, index,
                        AXI_PATH_4, axi_tr_if_4(index));

      end loop;
   end if;
end loop;
```

## AXI4 Example

```
-- Get the burst length of the read_trans transaction.
get_burst_length(burst_length, read_trans, index, AXI4_PATH_4,
                     axi4_tr_if_4(index));

-- Loop for the length of the data burst.
for i in  0 to burst_length loop

   -- Get the byte address and number of bytes in the data phase (beat).
   get_read_addr(read_trans,  i, 0, byte_length, addr, index,
                        AXI4_PATH_4, axi4_tr_if_4(index));

   -- Retrieve the first data byte from the slave memory using the
   -- slave test program do_byte_read procedure.
   do_byte_read(addr, data);

   -- Set the first read data byte for the read_trans transaction_id.
   set_read_data(read_trans, i, 0, byte_length, addr, data, index,
                     AXI4_PATH_4, axi4_tr_if_4(index));

   -- Loop for the number of bytes in the data phase (beat)
   -- given by the byte_length.
   if byte_length > 1 then
      for j in 1 to byte_length-1 loop

         -- Get the next read data byte address.
         get_read_addr(read_trans,  i, j, byte_length, addr, index,
                           AXI4_PATH_4, axi4_tr_if_4(index));

         -- Retrieve the next data byte from the slave memory using the
         -- slave test program do_byte_read procedure
         do_byte_read(addr, data);

         -- Set the read data byte for the read_trans transaction.
         set_read_data(read_trans, i, j, byte_length, addr, data,
                              index, AXI4_PATH_4, axi4_tr_if_4(index));
      end loop;
   end if;
end loop;
```

# set_read_data()

This nonblocking procedure sets a read *data* byte in a read transaction prior to execution. It is used in a slave test program as a helper procedure to set the read data retrieved from the slave memory into the relevant byte of a read data phase.

**Prototype**

```
-- * = axi | axi4
-- ** = AXI | AXI4
procedure set_read_data
(
   transaction_id  : in integer;
   index           : in integer;
   byte_index      : in integer;
   dynamic_size    : in integer;
   addr            : in std_logic_vector(**_MAX_BIT_SIZE-1
   downto 0);
   data            : in std_logic_vector(7 downto 0);
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| index | (Optional) Data byte array element number. |
| byte_index | Data byte index number of a particular data phase (beat). |
| dynamic_size | Maximum number of bytes in a particular data phase (beat). |
| addr | Read address. |
| data | Read data byte. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Wait for the write data burst to complete for the transaction.
get_burst_length(burst_length, read_trans, index, AXI_PATH_4,
                     axi_tr_if_4(index));

-- Loop for the length of the data burst.
for i in  0 to burst_length loop

   -- Get the byte address and number of bytes in the data phase (beat).
   get_read_addr(read_trans,  i, 0, byte_length, addr, index, AXI_PATH_4,
                  axi_tr_if_4(index));

   -- Retrieve the first data byte from the slave memory using the
   -- slave test program do_byte_read procedure.
   do_byte_read(addr, data);

   -- Set the first read data byte for the read_trans transaction.
   set_read_data(read_trans, i, 0, byte_length, addr, data, index,
                    AXI_PATH_4, axi_tr_if_4(index));

   -- Loop for the number of bytes in the data phase (beat)
   -- given by the byte_length.
   if byte_length > 1 then
      for j in 1 to byte_length-1 loop

         -- Get the next read data byte address.
         get_read_addr(read_trans,  i, j, byte_length, addr, index,
                          AXI_PATH_4, axi_tr_if_4(index));

         -- Retrieve the next data byte from the slave memory using the
         -- slave test program do_byte_read procedure.
         do_byte_read(addr, data);

         -- Set the next read data byte for the read_trans transaction.
         set_read_data(read_trans, i, j, byte_length, addr, data, index,
                         AXI_PATH_4, axi_tr_if_4(index));

      end loop;
   end if;
end loop;
```

## AXI4 Example

```
-- Get the burst length of the read_trans transaction.
get_burst_length(burst_length, read_trans, index, AXI4_PATH_4,
                    axi4_tr_if_4(index));

-- Loop for the length of the data burst.
for i in  0 to burst_length loop

   -- Get the byte address and number of bytes in the data phase (beat).
   get_read_addr(read_trans,  i, 0, byte_length, addr, index,
                       AXI4_PATH_4, axi4_tr_if_4(index));

   -- Retrieve the first data byte from the slave memory using the
   -- slave test program do_byte_read procedure.
   do_byte_read(addr, data);

   -- Set the first read data byte for the read_trans transaction_id.
   set_read_data(read_trans, i, 0, byte_length, addr, data, index,
                     AXI4_PATH_4, axi4_tr_if_4(index));

   -- Loop for the number of bytes in the data phase (beat)
   -- given by the byte_length.
   if byte_length > 1 then
      for j in 1 to byte_length-1 loop

         -- Get the next read data byte address.
         get_read_addr(read_trans,  i, j, byte_length, addr, index,
                         AXI4_PATH_4, axi4_tr_if_4(index));

         -- Retrieve the next data byte from the slave memory using the
         -- slave test program do_byte_read procedure
         do_byte_read(addr, data);

         -- Set the read data byte for the read_trans transaction.
         set_read_data(read_trans, i, j, byte_length, addr, data,
                           index, AXI4_PATH_4, axi4_tr_if_4(index));
      end loop;
   end if;
end loop;
```

# Chapter 10
# VHDL AXI3 and AXI4 Monitor BFMs

This section provides information about the VHDL AXI3 and AXI4 monitor BFMs. Each BFM has an API containing procedures that configure the BFM and access the dynamic Transaction Record during the lifetime of a transaction.

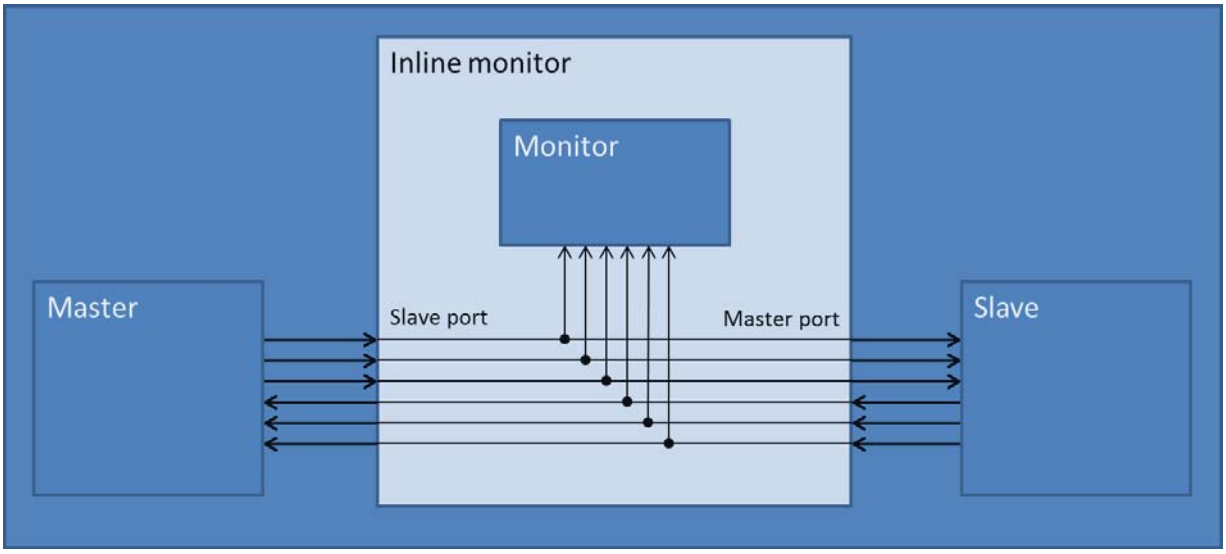
**Note**

Due to AXI3 protocol specification changes, for some BFM tasks, you reference the AXI3 BFM by specifying AXI instead of AXI3.

## Inline Monitor Connection

The connection of a monitor BFM to a test environment differs from that of a master and slave BFM. It is wrapped in an inline monitor interface and connected inline, between a master and slave, as shown in Figure 10-1. It has separate master and slave ports and monitors protocol traffic between a master and slave. By construction, the monitor has access to all the facilities provided by the monitor BFM.

**Figure 10-1. Inline Monitor Connection Diagram**



# Monitor BFM Protocol Support

The AXI3 monitor BFM supports the AMBA AXI3 protocol with restrictions detailed in "Protocol Restrictions" on page 1. In addition to the standard protocol, it supports user sideband signals *AWUSER* and *ARUSER*.

The AXI4 monitor BFM supports the AMBA AXI4 protocol with restrictions detailed in "Protocol Restrictions" on page 1.

# Monitor Timing and Events

For detailed timing diagrams of the protocol bus activity and details of the following monitor BFM API timing and events, refer to the relevant AMBA AXI Protocol Specification chapter,

The AMBA AXI Protocol specification does not define any timescale or clock period with signal events sampled and driven at rising *ACLK* edges. Therefore, the monitor BFM does not contain any timescale, timeunit, or timeprecision declarations with the signal setup and hold times specified in units of simulator time-steps.

# Monitor BFM Configuration

The AXI monitor BFMs support the full range of signals defined for the AMBA AXI protocol specification. The BFMs have parameters that can be used to configure the widths of the address, data and ID signals, and transaction fields to configure timeout factors, slave exclusive support, and setup and hold times, etc.

The address, data and ID signals widths can be changed from their default settings by assigning them with new values, usually performed in the top-level module of the testbench. These new values are then passed into the monitor BFM via a parameter port list of the monitor BFM component.

The following table lists the parameter names for the address, data and ID signals and their default values..

**Table 10-1. Signal Parameters**

| Signal Width Parameter | Description |
|---|---|
| **_ADDRESS_WIDTH | Address signal width in bits. This applies to the *ARADDR* and *AWADDR* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 64. |
| **_RDATA_WIDTH | Read data signal width in bits. This applies to the *RDATA* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 1024. |
| **_WDATA_WIDTH | Write data signal width in bits. This applies to the *WDATA* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 1024. |

**Table 10-1. Signal Parameters**

| Signal Width Parameter | Description |
|---|---|
| **_ID_WIDTH | ID signal width in bits. This applies to the *RID* and *WID* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 18. |
| AXI4_USER_WIDTH | (AXI4) User data signal width in bits. This applies to the *ARUSER*, *AWUSER*, *RUSER*, *WUSER* and *BUSER* signals. Refer to the AMBA AXI Protocol specification for more details. Default: 8. |
| AXI4_REGION_MAP_SIZE | (AXI4) Region signal width in bits. This applies to the ARREGION and AWREGION signals. Refer to the AMBA AXI Protocol specification for more details. Default: 16. |

A monitor BFM has configuration fields that you can set via the *set_config()* function to configure timeout factors, slave exclusive support, setup and hold times, etc. You can also get the value of a configuration field via the *get_config()* function. The full list of configuration fields is described in the table below.

**Table 10-2. AXI Monitor BFM Configuration**

| Configuration Field | Description |
|---|---|
| **Timing Variables** | |
| **_CONFIG_SETUP_TIME | The setup-time prior to the active edge of *ACLK*, in units of simulator time-steps for all signals.[1] Default: 0. |
| **_CONFIG_HOLD_TIME | The hold-time after the active edge of *ACLK*, in units of simulator time-steps for all signals.[1] Default: 0. |
| AXI_CONFIG_MAX_TRANSACTION_TIME_FACTOR | (AXI3) The maximum timeout duration for a read/write transaction in clock cycles. Default: 100000. |
| AXI_CONFIG_TIMEOUT_MAX_DATA_TRANSFER | (AXI3) The maximum number of write data beats that the AXI3 BFM can generate as part of write data burst of write transfer. Default: 1024. |
| _CONFIG_BURST_TIMEOUT_FACTOR | The maximum delay between the individual phases of a read/write transaction in clock cycles. Default: 10000. |
| AXI4_CONFIG_MAX_LATENCY_AWVALID_ ASSERTION_TO_AWREADY | (AXI4) The maximum timeout duration from the assertion of *AWVALID* to the assertion of *AWREADY* in clock periods (default 10000). |
| AXI4_CONFIG_MAX_LATENCY_ARVALID_ ASSERTION_TO_ARREADY | (AXI4) The maximum timeout duration from the assertion of *ARVALID* to the assertion of *ARREADY* in clock periods (default 10000). |

**Table 10-2. AXI Monitor BFM Configuration**

| Configuration Field | Description |
|---|---|
| **Timing Variables** | |
| AXI4_CONFIG_MAX_LATENCY_RVALID_ ASSERTION_TO_RREADY | (AXI4) The maximum timeout duration from the assertion of *RVALID* to the assertion of *RREADY* in clock periods (default 10000). |
| AXI4_CONFIG_MAX_LATENCY_BVALID_ ASSERTION_TO_BREADY | (AXI4) The maximum timeout duration from the assertion of *BVALID* to the assertion of *BREADY* in clock periods (default 10000). |
| AXI4_CONFIG_MAX_LATENCY_WVALID_ ASSERTION_TO_WREADY | (AXI4) The maximum timeout duration from the assertion of *WVALID* to the assertion of *WREADY i*n clock periods (default 10000). |
| **Master Attributes** | |
| AXI_CONFIG_WRITE_CTRL_TO_DATA_MINTIME | (AXI3) The minimum delay from the start of a write control (address) phase to the start of a write data phase in clock cycles. Default: 1. |
| AXI_CONFIG_MASTER_WRITE_DELAY | (AXI3) The master BFM applies the AXI_CONFIG_WRITE_CTRL_TO_ DATA_MINTIME value set.<br>0 = true (default)<br>1 = false |
| AXI_CONFIG_MASTER_DEFAULT_UNDER_RESET | (AXI3) The master BFM drives the *ARVALID*, *AWVALID* and *WVALID* signals low during reset:<br>0 = false (default)<br>1 = true |
| AXI4_CONFIG_ENABLE_QOS | (AXI4) The master participates in the Quality-of-Service scheme. If a master does not participate, the *AWQOS/ARQOS* value used in write/read transactions must be b0000. |
| **Slave Attributes** | |
| **_CONFIG_SUPPORT_EXCLUSIVE_ACCESS | Configures the support for an exclusive slave. If enabled the BFM will expect an *EXOKAY* response to a successful exclusive transaction. If disabled the BFM will expect an *OKAY* response to an exclusive transaction. Refer to the AMBA AXI protocol specification for more details.<br>0 = disabled<br>1 = enabled (default) |
| AXI_CONFIG_SLAVE_DEFAULT_UNDER_RESET | (AXI3) The slave BFM drives the *BVALID* and *RVALID* signals low during reset. Refer to the AMBA AXI Protocol specification for more details.<br>0 = false (default)<br>1 = true |

**Table 10-2. AXI Monitor BFM Configuration**

| Configuration Field | Description |
|---|---|
| **Slave Attributes** | |
| AXI4_CONFIG_SLAVE_START_ADDR | (AXI4) Configures the start address map for the slave. |
| AXI4_CONFIG_SLAVE_END_ADDR | (AXI4) Configures the end address map for the slave. |
| AXI4_CONFIG_READ_DATA_REORDERING_DEPTH | (AXI4) The slave read reordering depth. Refer to the AMBA AXI Protocol specification for more details. Default: 1. |
| **Error Detection** | |
| **_CONFIG_ENABLE_ALL_ASSERTIONS | Global enable/disable of all assertion checks in the BFM.<br>0 = disabled<br>1 = enabled (default) |

[1.] Refer to Monitor Timing and Events for details of simulator time-steps.

# Monitor Assertions

The monitor BFM performs protocol error checking via built-in assertions.

**Note**

The built-in BFM assertions are independent of programming language and simulator.

# AXI3 Assertion Configuration

By default, all built-in assertions are enabled in the monitor BFM. To globally disable them in the monitor BFM, use the *set_config()* command as the following example illustrates:

```
set_config(AXI_CONFIG_ENABLE_ALL_ASSERTIONS,0,bfm_index,
axi_tr_if_0(bfm_index));
```

Alternatively, you a disable individual built-in assertions by using a sequence of *get_config()* and *set_config()* commands on the respective assertion. For example, to disable assertion checking for the *AWLOCK* signal changing between the *AWVALID* and *AWREADY* handshake signals, use the following sequence of commands:

```
-- Define a local bit vector to hold the value of the assertion bit vector
variable config_assert_bitvector : std_logic_vector(AXI_MAX_BIT_SIZE-1
downto 0);

-- Get the current value of the assertion bit vector
get_config(AXI_CONFIG_ENABLE_ASSERTION, config_assert_bitvector,
bfm_index, axi_tr_if_0(bfm_index));

-- Assign the AXI_LOCK_CHANGED_BEFORE_AWREADY assertion bit to 0
config_assert_bitvector(AXI_LOCK_CHANGED_BEFORE_AWREADY) := '0';

-- Set the new value of the assertion bit vector
set_config(AXI_CONFIG_ENABLE_ASSERTION, config_assert_bitvector,
bfm_index, axi_tr_if_0(bfm_index));
```

**Note**

Do not confuse the *AXI_CONFIG_ENABLE_ASSERTION* bit vector with the *AXI_CONFIG_ENABLE_ALL_ASSERTIONS* global enable/disable.

To re-enable the *AXI_LOCK_CHANGED_BEFORE_AWREADY* assertion, following the above code sequence, assign the assertion in the *AXI_CONFIG_ENABLE_ASSERTION* bit vector to 1.

For a complete listing of assertions, refer to "AXI4 Assertions" on page 654.

## AXI4 Assertion Configuration

By default, all built-in assertions are enabled in the monitor BFM. To globally disable them in the monitor BFM, use the *set_config()* command as the following example illustrates:

```
set_config(AXI4_CONFIG_ENABLE_ALL_ASSERTIONS,0,bfm_index,
axi4_tr_if_0(bfm_index));
```

Alternatively, you a disable individual built-in assertions by using a sequence of *get_config()* and *set_config()* commands on the respective assertion. For example, to disable assertion checking for the *AWLOCK* signal changing between the *AWVALID* and *AWREADY* handshake signals, use the following sequence of commands:

```
-- Define a local bit vector to hold the value of the assertion bit vector
variable config_assert_bitvector : std_logic_vector(AXI4_MAX_BIT_SIZE-1
downto 0);

-- Get the current value of the assertion bit vector
get_config(AXI4_CONFIG_ENABLE_ASSERTION, config_assert_bitvector,
bfm_index, axi4_tr_if_0(bfm_index));

-- Assign the AXI4_LOCK_CHANGED_BEFORE_AWREADY assertion bit to 0
config_assert_bitvector(AXI4_LOCK_CHANGED_BEFORE_AWREADY) := '0';

-- Set the new value of the assertion bit vector
set_config(AXI4_CONFIG_ENABLE_ASSERTION, config_assert_bitvector,
bfm_index, axi4_tr_if_0(bfm_index));
```

**Note**

Do not confuse the *AXI4_CONFIG_ENABLE_ASSERTION* bit vector with the *AXI4_CONFIG_ENABLE_ALL_ASSERTIONS* global enable/disable.

To re-enable the *AXI4_LOCK_CHANGED_BEFORE_AWREADY* assertion, following the above code sequence, assign the assertion in the *AXI4_CONFIG_ENABLE_ASSERTION* bit vector to 1.

For a complete listing of assertions, refer to "AXI4 Assertions" on page 654.

# VHDL Monitor API

This section describes the VHDL Monitor API.

# set_config()

This nonblocking procedure sets the configuration of the monitor BFM.

## Prototype

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure set_config
(
   config_name    : in std_logic_vector(7 downto 0);
   config_val     : in std_logic_vector(**_MAX_BIT_SIZE-1
   downto 0)|integer;
   bfm_id         : in integer;
   path_id        : in *_path_t; --optional
   signal tr_if   : inout *_vhd_if_struct_t
);
```

## Arguments

config_name

(AXI3) Configuration name:
- AXI_CONFIG_SETUP_TIME
- AXI_CONFIG_HOLD_TIME
- AXI_CONFIG_MAX_TRANSACTION_TIME_FACTOR
- AXI_CONFIG_TIMEOUT_MAX_DATA_TRANSFER
- AXI_CONFIG_BURST_TIMEOUT_FACTOR
- AXI_CONFIG_WRITE_CTRL_TO_DATA_MINTIME
- AXI_CONFIG_MASTER_WRITE_DELAY
- AXI_CONFIG_MASTER_DEFAULT_UNDER_RESET
- AXI_CONFIG_SLAVE_DEFAULT_UNDER_RESET
- AXI_CONFIG_ENABLE_ALL_ASSERTIONS
- AXI_CONFIG_MASTER_ERROR_POSITION
- AXI_CONFIG_SUPPORT_EXCLUSIVE_ACCESS

(AXI4) Configuration name:
- AXI4_CONFIG_SETUP_TIME
- AXI4_CONFIG_HOLD_TIME
- AXI4_CONFIG_BURST_TIMEOUT_FACTOR
- AXI4_CONFIG_ENABLE_RLAST
- AXI4_CONFIG_ENABLE_SLAVE_EXCLUSIVE
- AXI4_CONFIG_ENABLE_ALL_ASSERTIONS
- AXI4_CONFIG_ENABLE_ASSERTION
- AXI4_CONFIG_MAX_LATENCY_AWVALID_ASSERTION_TO_AWREADY
- AXI4_CONFIG_MAX_LATENCY_ARVALID_ASSERTION_TO_ARREADY
- AXI4_CONFIG_MAX_LATENCY_RVALID_ASSERTION_TO_RREADY
- AXI4_CONFIG_MAX_LATENCY_BVALID_ASSERTION_TO_BREADY
- AXI4_CONFIG_MAX_LATENCY_WVALID_ASSERTION_TO_WREADY
- AXI4_CONFIG_ENABLE_QOS
- AXI4_CONFIG_READ_DATA_REORDERING_DEPTH
- AXI4_CONFIG_SLAVE_START_ADDR
- AXI4_CONFIG_SLAVE_END_ADDR

config_val

Refer to "Monitor BFM Configuration" on page 472 for description and valid values.

bfm_id

BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

| | | |
|---|---|---|
| | path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| | tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| **Returns** | None | |

## AXI3 Example

```
set_config(AXI_CONFIG_SUPPORT_EXCLUSIVE_ACCESS, 1, bfm_index,
      axi_tr_if_0(bfm_index));
set_config(AXI_CONFIG_BURST_TIMEOUT_FACTOR, 1000, bfm_index,
      axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
set_config(AXI4_CONFIG_SUPPORT_EXCLUSIVE_ACCESS, 1, bfm_index,
      axi4_tr_if_0(bfm_index));
set_config(AXI4_CONFIG_BURST_TIMEOUT_FACTOR, 1000, bfm_index,
      axi4_tr_if_0(bfm_index));
```

# get_config()

This nonblocking procedure gets the configuration of the monitor BFM.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure get_config
(
   config_name    : in std_logic_vector(7 downto 0);
   config_val     : out std_logic_vector(**_MAX_BIT_SIZE-1 downto
   0)|integer;
   bfm_id         : in integer;
   path_id        : in *_path_t; --optional
   signal tr_if   : inout *_vhd_if_struct_t
);
```

**Arguments**

config_name — (AXI3) Configuration name:

- AXI_CONFIG_SETUP_TIME
- AXI_CONFIG_HOLD_TIME
- AXI_CONFIG_MAX_TRANSACTION_TIME_FACTOR
- AXI_CONFIG_TIMEOUT_MAX_DATA_TRANSFER
- AXI_CONFIG_BURST_TIMEOUT_FACTOR
- AXI_CONFIG_WRITE_CTRL_TO_DATA_MINTIME
- AXI_CONFIG_WRITE_DATA_TO_CTRL_MINTIME
- AXI_CONFIG_MASTER_DEFAULT_UNDER_RESET
- AXI_CONFIG_SLAVE_DEFAULT_UNDER_RESET
- AXI_CONFIG_ENABLE_ALL_ASSERTIONS
- AXI_CONFIG_MASTER_ERROR_POSITION
- AXI_CONFIG_SUPPORT_EXCLUSIVE_ACCESS

(AXI4) Configuration name:

- AXI4_CONFIG_SETUP_TIME
- AXI4_CONFIG_HOLD_TIME
- AXI4_CONFIG_BURST_TIMEOUT_FACTOR
- AXI4_CONFIG_ENABLE_RLAST
- AXI4_CONFIG_ENABLE_SLAVE_EXCLUSIVE
- AXI4_CONFIG_ENABLE_ALL_ASSERTIONS
- AXI4_CONFIG_ENABLE_ASSERTION
- AXI4_CONFIG_MAX_LATENCY_AWVALID_ASSERTION_TO_AWREADY
- AXI4_CONFIG_MAX_LATENCY_ARVALID_ASSERTION_TO_ARREADY
- AXI4_CONFIG_MAX_LATENCY_RVALID_ASSERTION_TO_RREADY
- AXI4_CONFIG_MAX_LATENCY_BVALID_ASSERTION_TO_BREADY
- AXI4_CONFIG_MAX_LATENCY_WVALID_ASSERTION_TO_WREADY
- AXI4_CONFIG_ENABLE_QOS
- AXI4_CONFIG_READ_DATA_REORDERING_DEPTH
- AXI4_CONFIG_SLAVE_START_ADDR
- AXI4_CONFIG_SLAVE_END_ADDR

config_val — Refer to "Monitor BFM Configuration" on page 472 for description and valid values.

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

| | | |
|---|---|---|
| | path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| | tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| **Returns** | config_val | |

## AXI3 Example

```
get_config(AXI_CONFIG_SUPPORT_EXCLUSIVE_ACCESS, config_value, bfm_index,
     axi_tr_if_0(bfm_index));
get_config(AXI_CONFIG_BURST_TIMEOUT_FACTOR, config_value, bfm_index,
     axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
get_config(AXI4_CONFIG_SUPPORT_EXCLUSIVE_ACCESS, config_value,
     bfm_index, axi4_tr_if_0(bfm_index));
get_config(AXI4_CONFIG_BURST_TIMEOUT_FACTOR, config_value, bfm_index,
     axi4_tr_if_0(bfm_index));
```

# create_monitor_transaction()

This nonblocking procedure creates a monitor transaction. All transaction fields default to legal protocol values, unless previously assigned a value. It returns with the *transaction_id* argument.

## Prototype

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure create_monitor_transaction
(
   transaction_id  : out integer;
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

## Arguments

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

## Transaction Fields

| | |
|---|---|
| addr | Start address |
| size | Burst size. Default: width of bus:<br>**_BYTES_1;<br>**_BYTES_2;<br>**_BYTES_4;<br>**_BYTES_8;<br>**_BYTES_16;<br>**_BYTES_32;<br>**_BYTES_64;<br>**_BYTES_128; |
| burst | Burst type:<br>**_FIXED;<br>**_INCR; (default)<br>**_WRAP;<br>**_BURST_RSVD; |
| lock | Burst lock:<br>**_NORMAL; (default)<br>**_EXCLUSIVE;<br>**_LOCKED;<br>**_LOCK_RSVD; |

**Transaction Fields**

| | |
|---|---|
| cache | (AXI3) Burst cache:<br>AXI_NONCACHE_NONBUF; (default)<br>AXI_BUF_ONLY;<br>AXI_CACHE_NOALLOC;<br>AXI_CACHE_BUF_NOALLOC;<br>AXI_CACHE_RSVD0;<br>AXI_CACHE_RSVD1;<br>AXI_CACHE_WTHROUGH_ALLOC_R_ONLY;<br>AXI_CACHE_WBACK_ALLOC_R_ONLY;<br>AXI_CACHE_RSVD2;<br>AXI_CACHE_RSVD3;<br>AXI_CACHE_WTHROUGH_ALLOC_W_ONLY;<br>AXI_CACHE_WBACK_ALLOC_W_ONLY;<br>AXI_CACHE_RSVD4;<br>AXI_CACHE_RSVD5;<br>AXI_CACHE_WTHROUGH_ALLOC_RW;<br>AXI_CACHE_WBACK_ALLOC_RW;<br><br>(AXI4) Burst cache:<br>AXI4_NONMODIFIABLE_NONBUF; (default)<br>AXI4_BUF_ONLY;<br>AXI4_CACHE_NOALLOC;<br>AXI4_CACHE_2;<br>AXI4_CACHE_3;<br>AXI4_CACHE_RSVD4;<br>AXI4_CACHE_RSVD5;<br>AXI4_CACHE_6;<br>AXI4_CACHE_7;<br>AXI4_CACHE_RSVD8;<br>AXI4_CACHE_RSVD9;<br>AXI4_CACHE_10;<br>AXI4_CACHE_11;<br>AXI4_CACHE_RSVD12;<br>AXI4_CACHE_RSVD12;<br>AXI4_CACHE_14;<br>AXI4_CACHE_15; |
| prot | Burst protection:<br>**_NORM_SEC_DATA; (default)<br>**_PRIV_SEC_DATA;<br>**_NORM_NONSEC_DATA;<br>**_PRIV_NONSEC_DATA;<br>**_NORM_SEC_INST;<br>**_PRIV_SEC_INST;<br>**_NORM_NONSEC_INST;<br>**_PRIV_NONSEC_INST; |
| id | Burst ID |
| burst_length | (Optional) Burst length. Default: 0. |
| data_words | Data words array. |
| write_strobes | Write strobes array:<br>Each element 0 or 1. |
| resp | Burst response:<br>**_OKAY;<br>**_EXOKAY;<br>**_SLVERR;<br>**_DECERR; |
| region | (AXI4) Region identifier. |

| | | |
|---|---|---|
| **Transaction Fields** | qos | (AXI4) Quality-of-Service identifier. |
| | addr_user | Address channel user data. |
| | data_user | (AXI4) Data channel user data. |
| | resp_user | (AXI4) Response channel user data. |
| | read_or_write | Read or write transaction flag:<br>**_TRANS_READ;<br>**_TRANS_WRITE |
| **Operational Transaction Fields** | gen_write_strobes | Correction of write strobes for invalid byte lanes:<br>0 = write_strobes passed through to protocol signals.<br>1 = write_strobes auto-corrected for invalid byte lanes (default). |
| | operation_mode | Operation mode:<br>**_TRANSACTION_NON_BLOCKING;<br>**_TRANSACTION_BLOCKING (default); |
| | delay_mode | Delay mode:<br>**_VALID2READY (default);<br>**_TRANS2READY; |
| | write_data_mode | Write data mode:<br>**_DATA_AFTER_ADDRESS (default);<br>**_DATA_WITH_ADDRESS; |
| | address_valid_delay | Address channel *ARVALID/AWVALID* delay measured in *ACLK* cycles for this transaction. Default: 0. |
| | data_valid_delay | Data channel *RVALID/WVALID* delay measured in *ACLK* cycles for this transaction. Default: 0. |
| | write_response_valid_delay | Write response channel *BVALID* delay measured in *ACLK* cycles for this transaction. Default: 0). |
| | address_ready_delay | Address channel *ARREADY/AWREADY* delay measured in *ACLK* cycles for this transaction. Default: 0. |
| | data_ready_delay | Data channel *RREADY/WREADY* delay measured in *ACLK* cycles for this transaction. Default: 0. |
| | write_response_ready_delay | Write data channel *BREADY* delay measured in *ACLK* cycles for this transaction. Default: 0. |
| | data_beat_done | Read data channel phase (beat) *done* array for this transaction. |
| | transaction_done | Transaction *done* flag for this transaction |
| **Returns** | transaction_id | Transaction identifier. Refer to “Overloaded Procedure Common Arguments” on page 187. |

## AXI3 Example

```
-- Create a monitortransaction
-- Returns the transaction ID (tr_id) for this created transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_3(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction
-- Returns the transaction ID (tr_id) for this created transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_3(bfm_index));
```

# set_addr()

This nonblocking procedure sets the start address *addr* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_addr
(
   addr : in std_logic_vector(**_MAX_BIT_SIZE-1 downto 0) |
   integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| addr | Start address of transaction. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a Monitor Test Program.

# get_addr()

This nonblocking procedure gets the start address *addr* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_addr
(
   addr : out std_logic_vector(**_MAX_BIT_SIZE-1 downto 0) |
   integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| addr | Start address of transaction. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

| | |
|---|---|
| addr | Start address of transaction. |

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the start address addr of the tr_id transaction
get_addr(addr, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the start address addr of the tr_id transaction
get_addr(addr, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_size()

This nonblocking procedure sets the burst *size* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_size
(
   size : in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| size | Burst size. Default: width of bus:<br>**_BYTES_1;<br>**_BYTES_2;<br>**_BYTES_4;<br>**_BYTES_8;<br>**_BYTES_16;<br>**_BYTES_32;<br>**_BYTES_64;<br>**_BYTES_128; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a monitor test program.

# get_size()

This nonblocking procedure gets the burst *size* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_size
(
   size : out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

size — Burst size:
- **_BYTES_1;
- **_BYTES_2;
- **_BYTES_4;
- **_BYTES_8;
- **_BYTES_16;
- **_BYTES_32;
- **_BYTES_64;
- **_BYTES_128;

transaction_id — Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

path_id — (Optional) Parallel process path identifier:
- **_PATH_0
- **_PATH_1
- **_PATH_2
- **_PATH_3
- **_PATH_4

Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

tr_if — Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

**Returns**

size

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the burst size of the tr_id transaction.
get_size (size, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the burst size of the tr_id transaction.
get_size (size, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_burst()

This nonblocking procedure sets the *burst* type field for a transaction that is uniquely identified by the *transaction_id* field previously created by the create_monitor_transaction() procedure.

## Prototype

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_burst
(
   burst: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

## Arguments

| | |
|---|---|
| burst | Burst type:<br>**_FIXED;<br>**_INCR (default);<br>**_WRAP;<br>**_BURST_RSVD; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

## Returns

None

**Note**

You do not normally use this procedure in a monitor test program.

# get_burst()

This nonblocking procedure gets the *burst* type field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_burst
(
   burst: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| burst | Burst type:<br>**_FIXED;<br>**_INCR;<br>**_WRAP;<br>**_BURST_RSVD; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** burst

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the burst type of the tr_id transaction.
get_burst (burst, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the burst type of the tr_id transaction.
get_burst (burst, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_lock()

This nonblocking procedure sets the *lock* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_lock
(
   lock : in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| lock | Burst lock:<br>**_NORMAL (default);<br>**_EXCLUSIVE;<br>(AXI3) AXI_LOCKED;<br>(AXI3) AXI_LOCK_RSVD; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a monitor test program.

# get_lock()

This nonblocking procedure gets the *lock* field for a transaction that is uniquely identified by the transaction_id field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_lock
(
   lock : out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| lock | Burst lock:<br>**_NORMAL;<br>**_EXCLUSIVE;<br>(AXI3) AXI_LOCKED;<br>(AXI3) AXI_LOCK_RSVD; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** lock

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the lock field of the tr_id transaction.
get_lock(lock, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the lock field of the tr_id transaction.
get_lock(lock, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_cache()

This nonblocking procedure sets the *cache* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_cache
(
   cache: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

cache

(AXI3) Burst cache:
- AXI_NONCACHE_NONBUF; (default)
- AXI_BUF_ONLY;
- AXI_CACHE_NOALLOC;
- AXI_CACHE_BUF_NOALLOC;
- AXI_CACHE_RSVD0;
- AXI_CACHE_RSVD1;
- AXI_CACHE_WTHROUGH_ALLOC_R_ONLY;
- AXI_CACHE_WBACK_ALLOC_R_ONLY;
- AXI_CACHE_RSVD2;
- AXI_CACHE_RSVD3;
- AXI_CACHE_WTHROUGH_ALLOC_W_ONLY;
- AXI_CACHE_WBACK_ALLOC_W_ONLY;
- AXI_CACHE_RSVD4;
- AXI_CACHE_RSVD5;
- AXI_CACHE_WTHROUGH_ALLOC_RW;
- AXI_CACHE_WBACK_ALLOC_RW;

(AXI4) Burst cache:
- AXI4_NONMODIFIABLE_NONBUF; (default)
- AXI4_BUF_ONLY;
- AXI4_CACHE_NOALLOC;
- AXI4_CACHE_2;
- AXI4_CACHE_3;
- AXI4_CACHE_RSVD4;
- AXI4_CACHE_RSVD5;
- AXI4_CACHE_6;
- AXI4_CACHE_7;
- AXI4_CACHE_RSVD8;
- AXI4_CACHE_RSVD9;
- AXI4_CACHE_10;
- AXI4_CACHE_11;
- AXI4_CACHE_RSVD12;
- AXI4_CACHE_RSVD12;
- AXI4_CACHE_14;
- AXI4_CACHE_15;

transaction_id — Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

| | |
|---|---|
| path_id | (Optional) Parallel process path identifier:<br><br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

**Note**

You do not normally use this procedure in a monitor test program.

# get_cache()

This nonblocking procedure gets the *cache* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

## Prototype

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_cache
(
   cache: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

## Arguments

cache

(AXI3) Burst cache:
- AXI_NONCACHE_NONBUF; (default)
- AXI_BUF_ONLY;
- AXI_CACHE_NOALLOC;
- AXI_CACHE_BUF_NOALLOC;
- AXI_CACHE_RSVD0;
- AXI_CACHE_RSVD1;
- AXI_CACHE_WTHROUGH_ALLOC_R_ONLY;
- AXI_CACHE_WBACK_ALLOC_R_ONLY;
- AXI_CACHE_RSVD2;
- AXI_CACHE_RSVD3;
- AXI_CACHE_WTHROUGH_ALLOC_W_ONLY;
- AXI_CACHE_WBACK_ALLOC_W_ONLY;
- AXI_CACHE_RSVD4;
- AXI_CACHE_RSVD5;
- AXI_CACHE_WTHROUGH_ALLOC_RW;
- AXI_CACHE_WBACK_ALLOC_RW;

(AXI4) Burst cache:
- AXI4_NONMODIFIABLE_NONBUF; (default)
- AXI4_BUF_ONLY;
- AXI4_CACHE_NOALLOC;
- AXI4_CACHE_2;
- AXI4_CACHE_3;
- AXI4_CACHE_RSVD4;
- AXI4_CACHE_RSVD5;
- AXI4_CACHE_6;
- AXI4_CACHE_7;
- AXI4_CACHE_RSVD8;
- AXI4_CACHE_RSVD9;
- AXI4_CACHE_10;
- AXI4_CACHE_11;
- AXI4_CACHE_RSVD12;
- AXI4_CACHE_RSVD12;
- AXI4_CACHE_14;
- AXI4_CACHE_15;

transaction_id — Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

| | | |
|---|---|---|
| | path_id | (Optional) Parallel process path identifier:<br><br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| | tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| **Returns** | cache | |

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the cache field of the tr_id transaction.
get_cache(cache, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the cache field of the tr_id transaction.
get_cache(cache, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_prot()

This nonblocking procedure sets the protection *prot* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_prot
(
   prot: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| prot | Burst protection:<br>**_NORM_SEC_DATA (default);<br>**_PRIV_SEC_DATA;<br>**_NORM_NONSEC_DATA;<br>**_PRIV_NONSEC_DATA;<br>**_NORM_SEC_INST;<br>**_PRIV_SEC_INST;<br>**_NORM_NONSEC_INST;<br>**_PRIV_NONSEC_INST; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a monitor test program.

# get_prot()

This nonblocking procedure gets the protection *prot* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_prot
(
   prot: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| prot | Burst protection:<br>**_NORM_SEC_DATA;<br>**_PRIV_SEC_DATA;<br>**_NORM_NONSEC_DATA;<br>**_PRIV_NONSEC_DATA;<br>**_NORM_SEC_INST;<br>**_PRIV_SEC_INST;<br>**_NORM_NONSEC_INST;<br>**_PRIV_NONSEC_INST; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** prot

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the protection field of the tr_id transaction.
get_prot(prot, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the protection field of the tr_id transaction.
get_prot(prot, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_id()

This nonblocking procedure sets the *id* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_id
(
   id: in integer;
   transaction_id  : in std_logic_vector(**_MAX_BIT_SIZE-1 downto
   0) | integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| id | Burst ID |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a monitor test program.

# get_id()

This nonblocking procedure gets the *id* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_id
(
   id: out integer;
   transaction_id  : in std_logic_vector(**_MAX_BIT_SIZE-1 downto
   0) | integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| id | Burst ID |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the id field of the tr_id transaction.
get_id(id, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the id field of the tr_id transaction.
get_id(id, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_burst_length()

This nonblocking procedure sets the *burst_length* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Note**

The *burst_length* field is the value that appears on the *AWLEN* and the *ARLEN* protocol signals. The number of data phases (beats) in a data burst is therefore *burst_length* + 1.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_burst_length
(
   burst_length : in std_logic_vector(**_MAX_BIT_SIZE-1 downto 0)
   | integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| burst_length | Burst length (default = 0). |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a monitor test program.

# get_burst_length()

This nonblocking procedure gets the *burst_length* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Note**

The *burst_length* field is the value that appears on the *AWLEN* and the *ARLEN* protocol signals. The number of data phases (beats) in a data burst is therefore *burst_length* + 1.

**Prototype**

```
-- * = axi | axi4
-- ** = AXI | AXI4
get_burst_length
(
   burst_length : out std_logic_vector(**_MAX_BIT_SIZE-1 downto
   0) | integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| burst_length | Burst length. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** burst_length

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the burst length field of the tr_id transaction.
get_burst_length(burst_length, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the burst length field of the tr_id transaction.
get_burst_length(burst_length, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_data_words()

This nonblocking procedure sets the *data_words* field array elements for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_data_words
(
   data_words: in std_logic_vector(**_MAX_BIT_SIZE-1 downto 0) |
   integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| data_words | Data words array. |
| index | (Optional) Array element number for *data_words*. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a monitor test program.

# get_data_words()

This nonblocking procedure gets a *data_words* field array element for a transaction that is uniquely identified by the *transactionid* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_data_words
(
   data_words: out std_logic_vector(**_MAX_BIT_SIZE-1 downto 0) |
   integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| data_words | Data words array. |
| index | (Optional) Array element number for *data_words*. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

data_words

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the data_words field of the first data phase (beat)
-- for the tr_id transaction.
get_data_words(data, 0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Get the data_words field of the second data phase (beat)
-- for the tr_id transaction.
get_data_words(data, 1, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the data_words field of the first data phase (beat)
-- for the tr_id transaction.
get_data_words(data, 0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Get the data_words field of the second data phase (beat)
-- for the tr_id transaction.
get_data_words(data, 1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_write_strobes()

This nonblocking procedure sets the *write_strobes* field array elements for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure and uniquely identified by the *transaction_id* field.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_write_strobes
(
   write_strobes : in std_logic_vector (**_MAX_BIT_SIZE-1 downto 0)
   | integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| write_strobes | Write strobes array. |
| index | (Optional) Array element number for *write_strobes*. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a monitor test program.

# get_write_strobes()

This nonblocking procedure gets the *write_strobes* field array elements for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_write_strobes
(
   write_strobes : out std_logic_vector (**_MAX_BIT_SIZE-1 downto
   0) | integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| write_strobes | Write strobes array. |
| index | (Optional) Array element number for *write_strobes*. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

write_strobes

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Get the write_strobes field of the first data phase (beat)
-- for the tr_id transaction.
get_write_strobes(write_strobe, 0, tr_id, bfm_index,
axi_tr_if_0(bfm_index));

-- Get the write_strobes field of the second data phase (beat)
-- for the tr_id transaction.
get_write_strobes(write_strobe, 1, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Get the write_strobes field of the first data phase (beat)
-- for the tr_id transaction.
get_write_strobes(write_strobe, 0, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));

-- Get the write_strobes field of the second data phase (beat)
-- for the tr_id transaction.
get_write_strobes(write_strobe, 1, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_resp()

This nonblocking procedure sets the response *resp* field array elements for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_resp
(
   resp: in std_logic_vector (**_MAX_BIT_SIZE-1 downto 0) |
   integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| resp | Transaction response array:<br>**_OKAY = 0;<br>**_EXOKAY = 1;<br>**_SLVERR = 2;<br>**_DECERR = 3; |
| index | (Optional) Array element number for *resp*. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a monitor test program.

# get_resp()

This nonblocking procedure gets a response *resp* field array element for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_resp
(
   resp: out std_logic_vector (**_MAX_BIT_SIZE-1 downto 0) |
   integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

resp — Transaction response array:

**_OKAY = 0;
**_EXOKAY = 1;
**_SLVERR = 2;
**_DECERR = 3;

index — (Optional) Array element number for *resp*.

transaction_id — Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

path_id — (Optional) Parallel process path identifier:

**_PATH_0
**_PATH_1
**_PATH_2
**_PATH_3
**_PATH_4

Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

tr_if — Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

**Returns**

resp

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the response field of the first data phase (beat)
-- of the tr_id transaction.
get_resp(read_resp, 0, tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Get the response field of the second data phase (beat)
-- if the tr_id transaction.
get_resp(read_resp, 1, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the response field of the first data phase (beat)
-- of the tr_id transaction.
get_resp(read_resp, 0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Get the response field of the second data phase (beat)
-- if the tr_id transaction.
get_resp(read_resp, 1, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_addr_user()

This nonblocking procedure sets the user data *addr_user* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_addr_user
(
   addr_user : in std_logic_vector(**_MAX_BIT_SIZE-1 downto 0) |
   integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| addr_user | User data inin address phase. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a monitor test program.

# get_addr_user()

This nonblocking procedure gets the user data *addr_user* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_addr_user
(
   addr_user : out std_logic_vector(**_MAX_BIT_SIZE-1 downto 0) |
   integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| addr_user | User data in the address phase. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** addr_user

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the address channel user data of the tr_id transaction.
get_addr_user(user_data, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the address channel user data of the tr_id transaction.
get_addr_user(user_data, tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# set_read_or_write()

This procedure sets the *read_or_write* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the create_monitor_transaction() procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_read_or_write
(
   read_or_write: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| read_or_write | Read or write transaction:<br>**_TRANS_READ = 0<br>**_TRANS_WRITE = 1 |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a monitor test program.

# get_read_or_write()

This nonblocking procedure gets the *read_or_write* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_read_or_write
(
   read_or_write: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

read_or_write — Read or write transaction:

**_TRANS_READ = 0
**_TRANS_WRITE = 1

transaction_id — Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

path_id — (Optional) Parallel process path identifier:

**_PATH_0
**_PATH_1
**_PATH_2
**_PATH_3
**_PATH_4

Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

tr_if — Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

**Returns**

read_or_write

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the read_or_write field of tr_id transaction.
get_read_or_write(read_or_write, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the read_or_write field of tr_id transaction.
get_read_or_write(read_or_write, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_gen_write_strobes()

This nonblocking procedure sets the *gen_write_strobes* field for a write transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_gen_write_strobes
(
   gen_write_strobes: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| gen_write_strobes | Correction of write strobes for invalid byte lanes:<br>0 = *write_strobes* passed through to protocol signals.<br>1 = *write_strobes* auto-corrected for invalid byte lanes (default). |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a monitor test program.

# get_gen_write_strobes()

This nonblocking procedure gets the *gen_write_strobes* field for a write transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_gen_write_strobes
(
   gen_write_strobes: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| gen_write_strobes | Correct write strobes flag:<br><br>0 = *write_strobes* passed through to protocol signals.<br>1 = *write_strobes* auto-corrected for invalid byte lanes. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br><br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** gen_write_strobes

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify the
transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the auto correction write strobes flag of the tr_id transaction.
get_gen_write_strobes(write_strobes_flag, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify the
transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the auto correction write strobes flag of the tr_id transaction.
get_gen_write_strobes(write_strobes_flag, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_operation_mode()

This nonblocking procedure sets the *operation_mode* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_operation_mode
(
   operation_mode: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

operation_mode — Operation mode:

- **_TRANSACTION_NON_BLOCKING;
- **_TRANSACTION_BLOCKING (default);

transaction_id — Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

path_id — (Optional) Parallel process path identifier:

- **_PATH_0
- **_PATH_1
- **_PATH_2
- **_PATH_3
- **_PATH_4

Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

tr_if — Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

**Returns**

None

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Set the operation mode to nonblocking for the tr_id transaction.
set_operation_mode(AXI_TRANSACTION_NON_BLOCKING, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Set the operation mode to nonblocking for the tr_id transaction.
set_operation_mode(AXI4_TRANSACTION_NON_BLOCKING, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# get_operation_mode()

This nonblocking procedure gets the *operation_mode* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_operation_mode
(
   operation_mode: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| operation_mode | Operation mode:<br><br>**_TRANSACTION_NON_BLOCKING;<br>**_TRANSACTION_BLOCKING; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br><br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** operation_mode

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the operation mode of the tr_id transaction.
get_operation_mode(operation_mode, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the operation mode of the tr_id transaction.
get_operation_mode(operation_mode, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_delay_mode()

This AXI3 nonblocking procedure sets the *delay_mode* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_delay_mode
(
   delay_mode: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in axi_path_t; --optional
   signal tr_if : inout axi_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| delay_mode | Delay mode:<br><br>AXI_VALID2READY (default);<br>AXI_TRANS2READY; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br><br>AXI_PATH_0<br>AXI_PATH_1<br>AXI_PATH_2<br>AXI_PATH_3<br>AXI_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a monitor test program.

# get_delay_mode()

This AXI3 nonblocking procedure gets the *delay_mode* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_delay_mode
(
   delay_mode: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in axi_path_t; --optional
   signal tr_if : inout axi_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| delay_mode | Delay mode:<br>AXI_VALID2READY;<br>AXI_TRANS2READY; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI_PATH_0<br>AXI_PATH_1<br>AXI_PATH_2<br>AXI_PATH_3<br>AXI_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** delay_mode

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));
....
-- Get the delay mode of the *VALID to *READY handshake of the
-- tr_id transaction
get_delay_mode(delay_mode, tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 BFM

**Note**

This procedure is not supported in the AXI4 BFM API.

# set_write_data_mode()

This nonblocking procedure sets the *write_data_mode* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

## Prototype

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_write_data_mode
(
   write_data_mode: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

## Arguments

| | |
|---|---|
| write_data_mode | Write data mode:<br><br>**_DATA_AFTER_ADDRESS (default);<br>**_DATA_WITH_ADDRESS; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br><br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br><br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

## Returns

None

**Note**

You do not normally use this procedure in a monitor test program.

# get_write_data_mode()

This nonblocking procedure gets the *write_data_mode* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_write_data_mode
(
   write_data_mode: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| write_data_mode | Write data mode:<br>**_DATA_AFTER_ADDRESS;<br>**_DATA_WITH_ADDRESS; |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** write_data_mode

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the write data mode of the tr_id transaction
get_write_data_mode(write_data_mode, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the write data mode of the tr_id transaction
get_write_data_mode(write_data_mode, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_address_valid_delay()

This nonblocking procedure sets the *address_valid_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_address_valid_delay
(
   address_valid_delay: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| address_valid_delay | Address channel *ARVALID/AWVALID* delay measured in *ACLK* cycles for this transaction. Default: 0. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a monitor test program.

# get_address_valid_delay()

This nonblocking procedure gets the *address_valid_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_address_valid_delay
(
   address_valid_delay: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| address_valid_delay | Address channel *ARVALID/AWVALID* delay in *ACLK* cycles for this transaction. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** address_valid_delay

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the address channel delay of the tr_id transaction.
get_address_valid_delay(address_valid_delay, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the address channel delay of the tr_id transaction.
get_address_valid_delay(address_valid_delay, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_address_ready_delay()

This AXI3 nonblocking procedure sets the *address_ready_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedures.

**Prototype**

```
set_address_ready_delay
(
   address_ready_delay: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in axi_path_t; --optional
   signal tr_if : inout axi_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| address_ready_delay | Address channel *ARREADY/AWREADY* delay measured in *ACLK* cycles for this transaction. Default: 0. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI_PATH_0<br>AXI_PATH_1<br>AXI_PATH_2<br>AXI_PATH_3<br>AXI_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

**Note**

You do not normally use this procedure in a monitor test program.

# get_address_ready_delay()

This nonblocking procedure gets the *address_ready_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_address_ready_delay
(
   address_ready_delay: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| address_ready_delay | Address channel *ARREADY*/AWREADY delay measured in *ACLK* cycles for this transaction. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** address_ready_delay

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the address channel *READY delay of the tr_id transaction.
get_address_ready_delay(address_ready_delay, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the address channel *READY delay of the tr_id transaction.
get_address_ready_delay(address_ready_delay, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_data_valid_delay()

This nonblocking procedure sets the *data_valid_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_data_valid_delay
(
   data_valid_delay: in integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| data_valid_delay | Data channel array to hold *RVALID/WVALID* delays measured in *ACLK* cycles for this transaction. Default: 0. |
| index | (Optional) Array element number for *data_valid_delay*. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a monitor test program.

# get_data_valid_delay()

This nonblocking procedure sets the *data_valid_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_data_valid_delay
(
   data_valid_delay: out integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| data_valid_delay | Data channel array to hold *RVALID/WVALID* delays measured in *ACLK* cycles for this transaction. |
| index | (Optional) Array element number for *data_valid_delay*. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

data_valid_delay

## AXI3 Example

```
-- Create a monitor transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....
-- Get the write channel WVALID delay for the first data
-- phase (beat) of the tr_id transaction.
get_data_valid_delay(data_valid_delay, 0, tr_id, bfm_index,
axi_tr_if_0(bfm_index));

-- Get the write channel WVALID delay for the second data
-- phase (beat) of the tr_id transaction.
get_data_valid_delay(data_valid_delay, 1, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction with start address of 0.
-- Creation returns tr_id to identify the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....
-- Get the write channel WVALID delay for the first data
-- phase (beat) of the tr_id transaction.
get_data_valid_delay(data_valid_delay, 0, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));

-- Get the write channel WVALID delay for the second data
-- phase (beat) of the tr_id transaction.
get_data_valid_delay(data_valid_delay, 1, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_data_ready_delay()

This AXI3 nonblocking procedure sets the *data_ready_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
set_data_ready_delay
(
   data_ready_delay: in integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in axi_path_t; --optional
   signal tr_if : inout axi_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| data_ready_delay | Data channel array to hold *RREADY?WREADY* delays measured in *ACLK* cycles for this transaction. Default: 0. |
| index | (Optional) Array element number for *data_ready_delay*. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI_PATH_0<br>AXI_PATH_1<br>AXI_PATH_2<br>AXI_PATH_3<br>AXI_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

**Note**

You do not normally use this procedure in a monitor test program.

# get_data_ready_delay()

This nonblocking procedure gets the *data_ready_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_data_ready_delay
(
   data_ready_delay: out integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| data_ready_delay | Data channel array to hold *RREADY*/WREADY delay measured in *ACLK* cycles for this transaction. |
| index | (Optional) Array element index number for *data_ready_delay.* |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

-- Get the read data channel RREADY delay for the first
-- data phase (beat) of the tr_id transaction.
get_data_ready_delay(data_ready_delay, 0, tr_id, bfm_index,
axi_tr_if_0(bfm_index));

-- Get the read data channel RREADY delay for the second
-- data phase (beat) of the tr_id transaction.
get_data_ready_delay(data_ready_delay, 1, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

-- Get the read data channel RREADY delay for the first
-- data phase (beat) of the tr_id transaction.
get_data_ready_delay(data_ready_delay, 0, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));

-- Get the read data channel RREADY delay for the second
-- data phase (beat) of the tr_id transaction.
get_data_ready_delay(data_ready_delay, 1, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_write_response_valid_delay()

This AXI3 nonblocking procedure sets the *write_response_valid_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
set_write_response_valid_delay
(
   write_response_valid_delay: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in axi_path_t; --optional
   signal tr_if : inout axi_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| write_response_valid_delay | Write data channel *BVALID* delay measured in *ACLK* cycles for this transaction. Default: 0. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI_PATH_0<br>AXI_PATH_1<br>AXI_PATH_2<br>AXI_PATH_3<br>AXI_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a monitor test program.

# get_write_response_valid_delay()

This nonblocking procedure gets the *write_response_valid_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_write_response_valid_delay
(
   write_response_valid_delay: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| write_response_valid_delay | Write data channel *BVALID* delay measured in *ACLK* cycles for this transaction. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

| |
|---|
| write_response_valid_delay |

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the write response channel BVALID delay of the tr_id transaction.
get_write_response_valid_delay(write_response_valid_delay, tr_id,
bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the write response channel BVALID delay of the tr_id transaction.
get_write_response_valid_delay(write_response_valid_delay, tr_id,
bfm_index, axi4_tr_if_0(bfm_index));
```

# set_write_response_ready_delay()

This AXI3 nonblocking procedure sets the *write_response_ready_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
set_write_response_ready_delay
(
   write_response_ready_delay: in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in axi_path_t; --optional
   signal tr_if : inout axi_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| write_response_ready_delay | Write data channel *BREADY* delay measured in *ACLK* cycles for this transaction. Default: 0. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to v for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI_PATH_0<br>AXI_PATH_1<br>AXI_PATH_2<br>AXI_PATH_3<br>AXI_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a monitor test program.

# get_write_response_ready_delay()

This nonblocking procedure gets the *write_response_ready_delay* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi | axi4
-- ** = AXI | AXI4
get_write_response_ready_delay
(
   write_response_ready_delay: out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| write_response_ready_delay | Write data channel *BREADY* delay measured in *ACLK* cycles for this transaction. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

write_response_ready_delay

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the write response channel BREADY delay of the tr_id transaction.
get_write_response_ready_delay(write_resp_ready_delay, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the write response channel BREADY delay of the tr_id transaction.
get_write_response_ready_delay(write_resp_ready_delay, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_data_beat_done()

This nonblocking procedure sets the *data_beat_done* field array element for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_data_beat_done
(
   data_beat_done : in integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| data_beat_done | Write data channel phase (beat) *done* array for this transaction. |
| index | (Optional) Array element number for *data_beat_done*. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a monitor test program.

# get_data_beat_done()

This nonblocking procedure gets the *data_beat_done* field array element for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_data_beat_done
(
   data_beat_done : out integer;
   index : in integer; --optional
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| data_beat_done | Data channel phase (beat) *done* array for this transaction |
| index | (Optional) Array element number for *data_beat_done*. |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

data_beat_done

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....
-- Get the read data channel data_beat_done flag for the first
-- data phase (beat) of the tr_id transaction.
get_data_beat_done(data_beat_done, 0, tr_id, bfm_index,
axi_tr_if_0(bfm_index));

....
-- Get the read data channel data_beat_done flag for the second
-- data phase (beat) of the tr_id transaction.
get_data_beat_done(data_beat_done, 1, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....
-- Get the read data channel data_beat_done flag for the first
-- data phase (beat) of the tr_id transaction.
get_data_beat_done(data_beat_done, 0, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));

....
-- Get the read data channel data_beat_done flag for the second
-- data phase (beat) of the tr_id transaction.
get_data_beat_done(data_beat_done, 1, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# set_transaction_done()

This nonblocking procedure sets the *transaction_done* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedures.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
set_transaction_done
(
   transaction_done : in integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_done | Transaction *done* flag for this transaction |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

**Note**

You do not normally use this procedure in a monitor test program.

# get_transaction_done()

This nonblocking procedure gets the *transaction_done* field for a transaction that is uniquely identified by the *transaction_id* field previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
get_transaction_done
(
   transaction_done : out integer;
   transaction_id  : in integer;
   bfm_id : in integer;
   path_id : in *_path_t; --optional
   signal tr_if : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_done | Transaction *done* flag for this transaction |
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** transaction_done

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the transaction_done flag of the tr_id transaction.
get_transaction_done(transaction_done, tr_id, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the transaction_done flag of the tr_id transaction.
get_transaction_done(transaction_done, tr_id, bfm_index,
axi4_tr_if_0(bfm_index));
```

# get_read_data_burst()

This blocking procedure gets a read data burst that is uniquely identified by the *transaction_id* argument previously created by the *create_monitor_transaction()* procedure.

It calls the *get_read_data_phase()* procedure for each beat of the data burst, with the length of the burst defined by the transaction record *burst_length* field.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure get_read_data_burst
(
   transaction_id  : in integer;
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

transaction_id — Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

path_id — (Optional) Parallel process path identifier:

- **_PATH_0
- **_PATH_1
- **_PATH_2
- **_PATH_3
- **_PATH_4

Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

tr_if — Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

**Returns**

None

## AXI3 Example

```
-- Create a monitor transaction.
-- Creation returns tr_id to identify the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the read data burst for the tr_id transaction.
get_read_data_burst(tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction.
-- Creation returns tr_id to identify the transaction.
create_monitor_transaction(0, tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the read data burst for the tr_id transaction.
get_read_data_burst(tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_read_data_phase()

This blocking procedure gets a read data phase that is uniquely identified by the *transaction_id* argument previously created by the *create_monitor_transaction()* procedure.

The *get_read_data_phase()* sets the *data_beat_done* array *index* element field to 1 when the phase completes. If this is the last phase (beat) of the burst then it sets the *transaction_done* field to 1 to indicate the whole read transaction has completed.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure get_read_data_phase
(
   transaction_id  : in integer;
   index : in integer; --optional
   bfm_id          : in integer;
   path_id          : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| index | (Optional) Data phase (beat) number. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
-- Create a monitor transaction.
-- Creation returns tr_id to identify the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the read data phase for the first beat of the
-- tr_id transaction.
get_read_data_phase(tr_id, 0, bfm_index, axi_tr_if_0(bfm_index));

-- Get the read data phase for the second beat of the
-- tr_id transaction.
get_read_data_phase(tr_id, 1, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction.
-- Creation returns tr_id to identify the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the read data phase for the first beat of the
-- tr_id transaction.
get_read_data_phase(tr_id, 0, bfm_index, axi4_tr_if_0(bfm_index));

-- Get the read data phase for the second beat of the
-- tr_id transaction.
get_read_data_phase(tr_id, 1, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_write_response_phase()

This blocking procedure gets a write response phase that is uniquely identified by the *transaction_id* argument previously created by the *create_monitor_transaction()* procedure.

It sets the *transaction_done* field to 1 when the phase completes to indicate the whole transaction has completed.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure get_write_response_phase
(
   transaction_id  : in integer;
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

transaction_id — Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

path_id — (Optional) Parallel process path identifier:

**_PATH_0
**_PATH_1
**_PATH_2
**_PATH_3
**_PATH_4

Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

tr_if — Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

**Returns**

None

## AXI3 Example

```
-- Create a monitor transaction.
-- Creation returns tr_id to identify the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the write response phase for the tr_id transaction.
get_write_response_phase(tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction.
-- Creation returns tr_id to identify the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the write response phase for the tr_id transaction.
get_write_response_phase(tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_write_addr_phase()

This blocking procedure gets a write address phase that is uniquely identified by the *transaction_id* argument previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure get_write_addr_phase
(
   transaction_id  : in integer;
   bfm_id          : in integer;
   path_id         : in *_path_t; -- Optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the write address phase of the tr_id transaction.
get_write_addr_phase(tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the write address phase of the tr_id transaction.
get_write_addr_phase(tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_read_addr_phase()

This blocking procedure gets a read address phase that is uniquely identified by the *transaction_id* argument previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure get_read_addr_phase
(
   transaction_id  : in integer;
   bfm_id          : in integer;
   path_id         : in *_path_t; -- Optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the read address phase of the tr_id transaction.
get_read_addr_phase(tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the read address phase of the tr_id transaction.
get_read_addr_phase(tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_write_data_phase()

This blocking procedure gets a write data phase that is uniquely identified by the *transaction_id* argument previously created by the *create_monitor_transaction()* procedure.

The *get_write_data_phase()* sets the *data_beat_done* array *index* element to 1 when the phase completes. If this is the last data phase of the burst then it returns the *last* argument set to 1.

## Prototype

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure get_write_data_phase
(
   transaction_id  : in integer;
   index : in integer; --optional
   last : out integer;
   bfm_id          : in integer;
   path_id          : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

## Arguments

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| index | (Optional) Data phase (beat) number. |
| last | Last data phase (beat) of the burst:<br>0 = data burst not complete<br>1 = data burst complete |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

## Returns

last

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the write data phase for the first beat of the tr_id transaction.
get_write_data_phase(tr_id, 0, last, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the write data phase for the second beat of the tr_id transaction.
get_write_data_phase(tr_id, 1, last, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the write data phase for the first beat of the tr_id transaction.
get_write_data_phase(tr_id, 0, last, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the write data phase for the second beat of the tr_id transaction.
get_write_data_phase(tr_id, 1, last, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_write_data_burst()

This blocking procedure gets a write data burst that is uniquely identified by the *transaction_id* argument previously created by the *create_monitor_transaction()* procedure.

It calls the *get_write_data_phase()* procedure for each beat of the data burst, with the length of the burst defined by the transaction record *burst_length* field.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure get_write_data_burst
(
   transaction_id  : in integer;
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the write data burst for the tr_id transaction.
get_write_data_burst(tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the write data burst for the tr_id transaction.
get_write_data_burst(tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

# get_rw_transaction()

This blocking procedure gets a complete read/write transaction that is uniquely identified by the *transaction_id* argument previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure get_rw_transaction
(
   transaction_id  : in integer;
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

transaction_id — Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

path_id — (Optional) Parallel process path identifier:

- **_PATH_0
- **_PATH_1
- **_PATH_2
- **_PATH_3
- **_PATH_4

Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

tr_if — Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

**Returns**

None

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Get the complete tr_id transaction.
get_rw_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Get the complete tr_id transaction.
get_rw_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_read_addr_ready()

This blocking AXI4 procedure returns the value of the read address channel *ARREADY* signal using the *ready* argument. It will block for one *ACLK* period.

**Prototype**

```
procedure get_read_addr_ready
(
   ready : out integer;
   bfm_id          : in integer;
   path_id         : in axi4_adv_path_t; --optional
   signal tr_if    : inout axi4_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| ready | The value of the A*RREADY* signal. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI4_PATH_0<br>AXI4_PATH_1<br>AXI4_PATH_2<br>AXI4_PATH_3<br>AXI4_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** ready

## AXI3 BFM

**Note**

The *get_read_addr_ready()* procedure is not available in the AXI3 BFM.

## AXI4 Example

```
// Get the ARREADY signal value
bfm.get_read_addr_ready(ready, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_read_data_ready()

This blocking AXI4 procedure returns the value of the read data channel *RREADY* signal using the *ready* argument. It will block for one *ACLK* period.

**Prototype**

```
procedure get_read_data_ready
(
   ready : out integer;
   bfm_id          : in integer;
   path_id         : in axi4_adv_path_t; --optional
   signal tr_if    : inout axi4_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| ready | The value of the *RREADY* signal. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI4_PATH_0<br>AXI4_PATH_1<br>AXI4_PATH_2<br>AXI4_PATH_3<br>AXI4_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** ready

## AXI3 BFM

**Note**

The *get_read_data_ready()* procedure is not available in the AXI3 BFM.

## AXI4 Example

```
// Get the RREADY signal value
bfm.get_read_data_ready(ready, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_write_addr_ready()

This blocking AXI4 procedure returns the value of the write address channel *AWREADY* signal using the *ready* argument. It will block for one *ACLK* period.

**Prototype**

```
procedure get_write_addr_ready
(
   ready : out integer;
   bfm_id          : in integer;
   path_id         : in axi4_adv_path_t; --optional
   signal tr_if    : inout axi4_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| ready | The value of the *AWREADY* signal. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI4_PATH_0<br>AXI4_PATH_1<br>AXI4_PATH_2<br>AXI4_PATH_3<br>AXI4_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** ready

## AXI3 BFM

**Note**

The *get_write_addr_ready()* procedure is not available in the AXI3 BFM.

## AXI4 Example

```
// Get the WREADY signal value
bfm.get_write_addr_ready(ready, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_write_data_ready()

This blocking AXI4 procedure returns the value of the write data channel *WREADY* signal using the *ready* argument. It will block for one *ACLK* period.

**Prototype**

```
procedure get_write_data_ready
(
   ready : out integer;
   bfm_id          : in integer;
   path_id         : in axi4_adv_path_t; --optional
   signal tr_if    : inout axi4_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| ready | The value of the *WREADY* signal. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI4_PATH_0<br>AXI4_PATH_1<br>AXI4_PATH_2<br>AXI4_PATH_3<br>AXI4_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** ready

## AXI3 BFM

**Note**

The *get_write_data_ready()* procedure is not available in the AXI3 BFM.

## AXI4 Example

```
// Get the WREADY signal value
bfm.get_write_data_ready(ready, bfm_index, axi4_tr_if_0(bfm_index));
```

# get_write_resp_ready()

This blocking AXI4 procedure returns the value of the write response channel *BREADY* signal using the *ready* argument. It blocks for one *ACLK* period.

**Prototype**

```
procedure get_write_resp_ready
(
   ready : out integer;
   bfm_id          : in integer;
   path_id         : in axi4_adv_path_t; --optional
   signal tr_if    : inout axi4_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| ready | The value of the *RREADY* signal. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>AXI4_PATH_0<br>AXI4_PATH_1<br>AXI4_PATH_2<br>AXI4_PATH_3<br>AXI4_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** ready

## AXI3 BFM

**Note**

The *get_write_resp_ready()* procedure is not available in the AXI3 BFM.

## AXI4 Example

```
// Get the BREADY signal value
bfm.get_write_resp_ready(ready, bfm_index, axi4_tr_if_0(bfm_index));
```

# push_transaction_id()

This nonblocking procedure pushes a transaction record into the back of a queue. The transaction is uniquely identified by the *transaction_id* argument previously created by the *create_monitor_transaction()* procedure. The queue is identified by the *queue_id* argument.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure push_transaction_id
(
   transaction_id  : in integer;
   queue_id  : in integer;
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

transaction_id — Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

queue_id — Queue identifier:

**_QUEUE_ID_0
**_QUEUE_ID_1
**_QUEUE_ID_2
**_QUEUE_ID_3
**_QUEUE_ID_4

Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

path_id — (Optional) Parallel process path identifier:

**_PATH_0
**_PATH_1
**_PATH_2
**_PATH_3
**_PATH_4

Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

tr_if — Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

**Returns**

None

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Push the transaction record into queue 1 for the tr_id transaction.
push_transaction_id(tr_id, AXI_QUEUE_ID_1, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Push the transaction record into queue 1 for the tr_id transaction.
push_transaction_id(tr_id, AXI4_QUEUE_ID_1, bfm_index,
axi4_tr_if_0(bfm_index));
```

# pop_transaction_id()

This nonblocking (unless queue is empty) procedure pops a transaction record from the front of a queue. The transaction is uniquely identified by the *transaction_id* argument previously created by the *get_rw_transaction()* procedure. The queue is identified by the *queue_id* argument.

If the queue is empty then it will block until an entry becomes available.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure pop_transaction_id
(
   transaction_id  : in integer;
   queue_id  : in integer;
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

transaction_id — Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

queue_id — Queue identifier:

**_QUEUE_ID_0
**_QUEUE_ID_1
**_QUEUE_ID_2
**_QUEUE_ID_3
**_QUEUE_ID_4

Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

bfm_id — BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

path_id — (Optional) Parallel process path identifier:

**_PATH_0
**_PATH_1
**_PATH_2
**_PATH_3
**_PATH_4

Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

tr_if — Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details.

**Returns**

None

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Pop the transaction record from queue 1 for the tr_id transaction.
pop_transaction_id(tr_id, AXI_QUEUE_ID_1, bfm_index,
axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Pop the transaction record from queue 1 for the tr_id transaction.
pop_transaction_id(tr_id, AXI4_QUEUE_ID_1, bfm_index,
axi4_tr_if_0(bfm_index));
```

# print()

This nonblocking procedure prints a transaction record, that is uniquely identified by the *transaction_id* argument previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure print
(
   transaction_id  : in integer;
   print_delays : in integer; --optional
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| print_delays | (Optional) Print delay values flag:<br>0 = do not print the delay values (default).<br>1 = print the delay values. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Print the transaction record (including delay values) of the
-- tr_id transaction.
print(tr_id, 1, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Print the transaction record (including delay values) of the
-- tr_id transaction.
print(tr_id, 1, bfm_index, axi4_tr_if_0(bfm_index));
```

# destruct_transaction()

This blocking procedure removes a transaction record, for clean-up purposes and memory management, that is uniquely identified by the *transaction_id* argument previously created by the *create_monitor_transaction()* procedure.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure destruct_transaction
(
   transaction_id  : in integer;
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| transaction_id | Transaction identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns** None

## AXI3 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));

....

-- Remove the transaction record for the tr_id transaction.
destruct_transaction(tr_id, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
-- Create a monitor transaction. Creation returns tr_id to identify
-- the transaction.
create_monitor_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));

....

-- Remove the transaction record for the tr_id transaction.
destruct_transaction(tr_id, bfm_index, axi4_tr_if_0(bfm_index));
```

# wait_on()

This blocking procedure waits for an event on the *ACLK* or *ARESETn* signals to occur before proceeding. An optional *count* argument waits for the number of events equal to *count*.

**Prototype**

```
-- * = axi| axi4
-- ** = AXI | AXI4
procedure wait_on
(
   phase           : in integer;
   count: in integer; --optional
   bfm_id          : in integer;
   path_id         : in *_path_t; --optional
   signal tr_if    : inout *_vhd_if_struct_t
);
```

**Arguments**

| | |
|---|---|
| phase | Wait for:<br>**_CLOCK_POSEDGE<br>**_CLOCK_NEGEDGE<br>**_CLOCK_ANYEDGE<br>**_CLOCK_0_TO_1<br>**_CLOCK_1_TO_0<br>**_RESET_POSEDGE<br>**_RESET_NEGEDGE<br>**_RESET_ANYEDGE<br>**_RESET_0_TO_1<br>**_RESET_1_TO_0 |
| count | (Optional) Wait for a number of events to occur set by *count*. (default = 1) |
| bfm_id | BFM identifier. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| path_id | (Optional) Parallel process path identifier:<br>**_PATH_0<br>**_PATH_1<br>**_PATH_2<br>**_PATH_3<br>**_PATH_4<br>Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |
| tr_if | Transaction signal interface. Refer to "Overloaded Procedure Common Arguments" on page 187 for more details. |

**Returns**

None

## AXI3 Example

```
wait_on(AXI_RESET_POSEDGE, bfm_index, axi_tr_if_0(bfm_index));
wait_on(AXI_CLOCK_POSEDGE, 10, bfm_index, axi_tr_if_0(bfm_index));
```

## AXI4 Example

```
wait_on(AXI4_RESET_POSEDGE, bfm_index, axi4_tr_if_0(bfm_index));
wait_on(AXI4_CLOCK_POSEDGE, 10, bfm_index, axi4_tr_if_0(bfm_index));
```

# Chapter 11
# VHDL Tutorials

This chapter discusses how to use the Mentor Verification IP Altera Edition master and slave BFMs to verify slave and master components, respectively.

In the Verifying a Slave DUT tutorial the slave is an on-chip RAM model that is verified using a master BFM and test program.

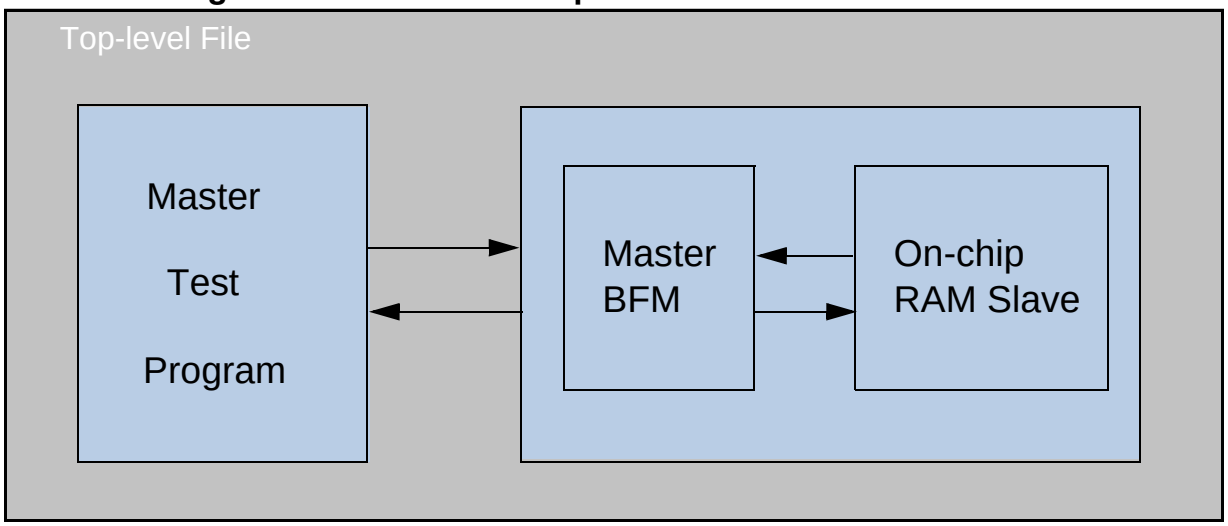
In the Verifying a Master DUT tutorial the master issues simple write and read transactions that are verified using a slave BFM and test program.

Following this top-level discussion of how you verify a master and a slave component using the Mentor Verification IP Altera Edition is a brief example of how to run Qsys, the powerful system integration tool in the Quartus II software. This procedure shows you how to use Qsys to create a top-level DUT environment. For more details on this example, refer to "Getting Started with Qsys and the BFMs" on page 629.

## Verifying a Slave DUT

A slave DUT component is connected to a master BFM at the signal-level. A master test program, written at the transaction-level, generates stimulus via the master BFM to verify the slave DUT. Figure 11-1 illustrates a typical top-level testbench environment.

**Figure 11-1. Slave DUT Top-level Testbench Environment**



In this example the master test program also compares the written data with that read back from the slave DUT, reporting the result of the comparison.

A top-level file instantiates and connects all the components required to test and monitor the DUT, and controls the system clock (*ACLK*) and reset (*ARESETn*) signals.

## AXI3 BFM Master Test Program

Using the AXI3 master BFM API, this Master Test Program creates a wide range of stimulus scenarios which test the slave DUT. This tutorial restricts the stimulus to a write transaction followed by a read transaction to the same address, which then compares the read data with the previously written data. For a complete code example of this VHDL Master Test Program, refer to "VHDL AXI3 Master BFM Test Program" on page 687 in Appendix B.

The code excerpt in Example 11-1 shows the Master Test Program architecture definition *master_test_program_a*. It defines three variables, *tr_id*, *data_words*, and *lp* to hold the transaction identifier number, data words payload, and read data from slave, respectively. An additional system clock cycle is waited on after reset to satisfy the AXI3 protocol requirement specified in Section 11.1.2 of the AMBA AXI Protocol Specification before executing transactions.

**Example 11-1. Architecture Definition and Initialization**

```
architecture master_test_program_a of master_test_program is
begin

   -- Master test
   process
   variable tr_id: integer;
   variable data_words :  std_logic_vector(AXI_MAX_BIT_SIZE-1 downto 0);
   variable lp: line;

   begin
      wait_on(AXI_RESET_POSEDGE, index, axi_tr_if_0(index));
      wait_on(AXI_CLOCK_POSEDGE, index, axi_tr_if_0(index));
```

To generate AXI3 protocol traffic, the Master Test Program must create the transaction before executing it. The code excerpt in Example 11-2 uses the VHDL Master API create_write_transaction() procedure to provide only the start address argument of the transaction to be created. Because this procedure call provides only the start address, the burst-length argument automatically defaults to a value of zero—indicating a burst length of a single beat.

This example has an AXI3 data bus width of 32-bits; therefore a single beat of data conveys 4-bytes across the data bus. The *set_data_words()* procedure sets the '*data_words[0]*' transaction field with the value of 1 on byte lane 1, resulting in a value of 32'h0000_0100. However, the AXI3 protocol permits narrow transfers with the use of the write strobes signal *WSTRB* to

indicate which byte lane contains valid write data. Similarly, you can use the *set_write_strobes()* procedure to set the *write_strobes[0]* transaction field with the value of 4'b0010, indicating that only valid data is being transferred on byte lane 1. The write transaction then executes on the protocol signals using the "execute_transaction()" on page 297.

All other transaction fields default to legal protocol values for more details).

### Example 11-2. Write Transaction Creation and Execution

```
-- Write data value 1 on byte lanes 1 to address 1.
create_write_transaction(1, tr_id, index, axi_tr_if_0(index));
data_words(31 downto 0) := x"00000100";
set_data_words(data_words, tr_id, index, axi_tr_if_0(index));
set_write_strobes(2, tr_id, index, axi_tr_if_0(index));
report "master_test_program: Writing data (1) to address (1)";

-- By default it will run in Blocking mode
execute_transaction(tr_id, index, axi_tr_if_0(index));
```

The code excerpt in Example 11-3 uses the "VHDL AXI3 Master BFM" to read the data that has just been written into the slave memory. The Master Test Program first creates a read transaction using the *create_read_transaction()* procedure and provides only the start address argument of the transaction to be created. Because this procedure call provides only the start address, the burst-length automatically defaults to a value of zero—indicating a burst length of a single beat.

The *set_id()* procedure sets the transaction *id* field to be 1 and the *set_size()* procedure sets the transaction *size* field to be a single byte, before executing the read transaction onto the protocol signals.

The read data is obtained using the *get_data_words()* procedure to get the *data_words* transaction field value. The result of the read data is compared with the expected data—and a report message displays the result.

### Example 11-3. Read Transaction Creation and Execution

```
--Read data from address 1.
create_read_transaction(1, tr_id, index, axi_tr_if_0(index));
set_id(1, tr_id, index, axi_tr_if_0(index));
set_size(AXI_BYTES_1, tr_id, index, axi_tr_if_0(index));
execute_transaction(tr_id, index, axi_tr_if_0(index));

get_data_words(data_words, tr_id, index, axi_tr_if_0(index));
if(data_words(31 downto 0) = x"00000100") then
      report "master_test_program: Read correct data (1) at address (1)";
else
      hwrite(lp, data_words(31 downto 0));
      report "master_test_program: Error: Expected data (1) at address 1,
      but got " & lp.all;
end if;
```

# AXI4 BFM Master Test Program

A master test program using the master BFM API is capable of creating a wide range of stimulus scenarios to verify a slave DUT. However, this tutorial restricts the master BFM stimulus to write transactions followed by read transactions to the same address, and then compares the read data with the previously written data. For a complete code listing of this master test program, refer to "VHDL AXI4 Master BFM Test Program" on page 698.

The master test program contains:

- A create_transactions process that creates and executes read and write transactions.
- Processes *handle_write_resp_ready* and *handle_read_data_ready* to handle the write response channel *BREADY* and read data channel *RREADY* signals, respectively.
- Variables *m_wr_resp_phase_ready_delay* and *m_rd_data_phase_ready_delay* to set the delay of the *BREADY and RREADY* signals

The following sections described the main processes and variables:

## m_wr_resp_phase_ready_delay

The *m_wr_resp_phase_ready_delay* variable holds the *BREADY* signal delay. The delay value extends the length of the write response phase by a number of *ACLK* cycles.

Example 11-4 below shows the *AWREADY* signal delayed by 2 *ACLK* cycles. You can edit this variable to change the *AWREADY* signal delay.

**Example 11-4. m_wr_resp_phase_ready_delay**

```
-- Variable : m_wr_resp_phase_ready_delay
signal m_wr_resp_phase_ready_delay :integer := 2;
```

## m_rd_data_phase_ready_delay

The *m_rd_data_phase_ready_delay* variable holds the *RREADY* signal delay. The delay value extends the length of each read data phase (beat) in a read data burst by a number of *ACLK* cycles.

Example 11-5 below shows the *RREADY* signal delayed by 2 *ACLK* cycles. You can edit this variable to change the *RREADY* signal delay.

**Example 11-5. m_rd_data_phase_ready_delay**

```
-- Variable : m_rd_data_phase_ready_delay
signal m_rd_data_phase_ready_delay : integer := 2;
```

## create_transactions

The create transactions process creates and executes read and write transactions. The whole process runs concurrently with other processes in the test program, using the *path_id* = *AXI4_PATH_0* (see Overloaded Procedure Common Arguments for details of *path_id*).

The process waits for the *ARESETn* signal to be deasserted, followed by a positive *ACLK* edge, as Example 11-7 illustrates. This satisfies the protocol requirements in section A3.1.2 of the Protocol Specification.

### Example 11-6. Wait for *ARESETn D*eassertion Then Positive *ACLK* Edge

```
-- Master test
process
   variable tr_id: integer;
   variable data_words :  std_logic_vector(AXI4_MAX_BIT_SIZE-1 downto 0);
   variable lp: line;
   begin
      wait_on(AXI4_RESET_POSEDGE, index, axi4_tr_if_0(index));
      wait_on(AXI4_CLOCK_POSEDGE, index, axi4_tr_if_0(index));
```

To generate protocol traffic a master transaction must be created before executing it. The *create_write_transaction()* procedure is used to create a write transaction, passing in the start address of 1 as an argument to the procedure, as shown in Example 11-7. The burst-length argument automatically defaults to a value of zero—indicating a burst length of a single beat.

This example has a write data bus width of 32-bits; therefore a single beat of data conveys 4-bytes across the data bus. The *set_data_words()* procedure call loads the first element of the *data_words[0]* transaction field with the value 1 on byte lane 1, with result of *x"0000_0100"*.

The write strobes *WSTRB* signal indicates to the slave which byte lane contains valid write data to be written to the slave memory. The *set_write_strobes()* procedure call loads the first element of the *write_strobes* transaction field with the value 2, indicating that only byte lane 1 contains valid data. All other transaction fields default to legal protocol values (see the *create_write_transaction()* procedure for details).

Calling the *execute_transaction()* procedure executes the *trans* transaction on the protocol signals.

### Example 11-7. Write Transaction Creation and Execution

```
-- 4 x Writes
-- Write data value 1 on byte lanes 1 to address 1.
create_write_transaction(1, tr_id, index, axi4_tr_if_0(index));
data_words(31 downto 0) := x"00000100";
set_data_words(data_words, tr_id, index, axi4_tr_if_0(index));
set_write_strobes(2, tr_id, index, axi4_tr_if_0(index));
report "master_test_program: Writing data (1) to address (1)";

-- By default it will run in Blocking mode
execute_transaction(tr_id, index, axi4_tr_if_0(index));
```

The process creates another three write transactions similar to the transaction shown in Example 11-7, but with different start addresses and payload data.

The payload data previously written to the slave is read back and compared, reporting the outcome of the comparison. The *create_read_transaction()* procedure creates a read transaction, passing in the start address of 1 as an argument to the procedure, as shown in the Example 11-8. The *burst_length* argument automatically defaults to a value of zero—indicating a burst length of a single beat.

The *set_size()* procedure call sets the transaction *size* field to a single byte and the *set_id()* procedure call sets the transaction *id* field to be 1. The read transaction is then executed on the protocol signals by calling the *execute_transaction()* procedure.

The read data is obtained using the *get_data_words()* procedure to get the *data_words* transaction field value. The result of the read data is compared with the expected data—and a message displays the result.

### Example 11-8. Read Transaction Creation and Execution

```
--4 x Reads
--Read data from address 1.
create_read_transaction(1, tr_id, index, axi4_tr_if_0(index));
set_id(1, tr_id, index, axi4_tr_if_0(index));
set_size(AXI4_BYTES_1, tr_id, index, axi4_tr_if_0(index));
execute_transaction(tr_id, index, axi4_tr_if_0(index));

get_data_words(data_words, tr_id, index, axi4_tr_if_0(index));
if(data_words(31 downto 0) = x"00000100") then
   report "master_test_program: Read correct data (1) at address (1)";
else
   hwrite(lp, data_words(31 downto 0));
   report "master_test_program: Error: Expected data (1) at address 1, but
got " & lp.all;
end if;
```

The process creates three more read transactions similar to the transaction shown in Example 11-8, but with start addresses aligned to those previously used for the write transactions.

The code to create a write burst transaction that contains several data transfers (beats) is similar to that for a single transfer described earlier. The master BFM *create_write_transaction()* procedure creates a write transaction, passing in the start address and burst length as arguments to the function, as shown in Example 11-9.

**Note**

The burst length argument passed to the *create_write_transaction()* procedure is 1 less than the number of transfers (beats) in the burst. This aligns the burst length argument value with the value placed on the *AWLEN* protocol signals.

The *set_write_data_mode()* procedure call sets the *write_data_mode* transaction field to start the write data burst simultaneously with the address phase of the transaction, before executing the transaction onto the protocol signals.

**Example 11-9. Write Burst Transaction Creation and Execution**

```
--  Write data burst length of 7 to start address 16.
create_write_transaction(16, 7, tr_id, index, axi4_tr_if_0(index));
data_words(31 downto 0) := x"ACE0ACE1";
set_data_words(data_words, 0, tr_id, index, axi4_tr_if_0(index));
data_words(31 downto 0) := x"ACE2ACE3";
set_data_words(data_words, 1, tr_id, index, axi4_tr_if_0(index));
data_words(31 downto 0) := x"ACE4ACE5";
set_data_words(data_words, 2, tr_id, index, axi4_tr_if_0(index));
data_words(31 downto 0) := x"ACE6ACE7";
set_data_words(data_words, 3, tr_id, index, axi4_tr_if_0(index));
data_words(31 downto 0) := x"ACE8ACE9";
set_data_words(data_words, 4, tr_id, index, axi4_tr_if_0(index));
data_words(31 downto 0) := x"ACEAACEB";
set_data_words(data_words, 5, tr_id, index, axi4_tr_if_0(index));
data_words(31 downto 0) := x"ACECACED";
set_data_words(data_words, 6, tr_id, index, axi4_tr_if_0(index));
data_words(31 downto 0) := x"ACEEACEF";
set_data_words(data_words, 7, tr_id, index, axi4_tr_if_0(index));
for i in  0 to 7 loop
   set_write_strobes(15, i, tr_id, index, axi4_tr_if_0(index));
end loop;
set_write_data_mode(AXI4_DATA_WITH_ADDRESS, tr_id, index,
axi4_tr_if_0(index));
execute_transaction(tr_id, index, axi4_tr_if_0(index));
```

The process then creates another write burst transaction, similar to the transaction explained in Example 11-9, but setting the byte lane zero write strobe to be invalid. Selected locations containing valid data in the slave memory are then read back and compared with the data previously written.

## handle_write_resp_ready

The *handle write response ready* process handles the *BREADY* signal for the write response channel. The whole process runs concurrently with other processes in the test program, using the *path_id* = *AXI4_PATH_5* (see Overloaded Procedure Common Arguments for details of *path_id*), as shown in the Example 11-10.

The initial wait for the *ARESETn* signal to be deactivated, followed by a positive *ACLK* edge, satisfies the protocol requirement detailed in section A3.1.2 of the Protocol Specification.

The *BREADY* signal is deasserted using the nonblocking call to the *execute_write_resp_ready()* procedure and waits for a write channel response phase to occur with a call to the blocking *get_write_response_cycle()* procedure. A received write response phase indicates that the *BVALID* signal has been asserted, triggering the starting point for the delay of the *BREADY* signal. In a *loop* it delays the assertion of *BREADY* based on the setting of the

*m_wr_resp_phase_ready_delay* variable. After the delay, another call to the *execute_write_resp_ready()* procedure to assert the *BREADY* signal completes the *BREADY* handling.

**Example 11-10. Process handle_write_resp_ready**

```
-- handle_write_resp_ready : write response ready through path 5.
-- This method assert/de-assert the write response channel ready signal.
-- Assertion and de-assertion is done based on following variable's value:
-- m_wr_resp_phase_ready_delay
process
   variable tmp_ready_delay : integer;
begin
   wait_on(AXI4_RESET_POSEDGE, index, AXI4_PATH_5, axi4_tr_if_5(index));
   wait_on(AXI4_CLOCK_POSEDGE, index, AXI4_PATH_5, axi4_tr_if_5(index));
   loop
      wait until m_wr_resp_phase_ready_delay > 0;
      tmp_ready_delay := m_wr_resp_phase_ready_delay;
      execute_write_resp_ready(0, 1, index, AXI4_PATH_5,
axi4_tr_if_5(index));
      get_write_response_cycle(index, AXI4_PATH_5, axi4_tr_if_5(index));
      if(tmp_ready_delay > 1) then
         for i in  0 to tmp_ready_delay-2 loop
            wait_on(AXI4_CLOCK_POSEDGE, index, AXI4_PATH_5,
axi4_tr_if_5(index));
         end loop;
      end if;
      execute_write_resp_ready(1, 1, index, AXI4_PATH_5,
axi4_tr_if_5(index));
   end loop;
   wait;
end process;
```

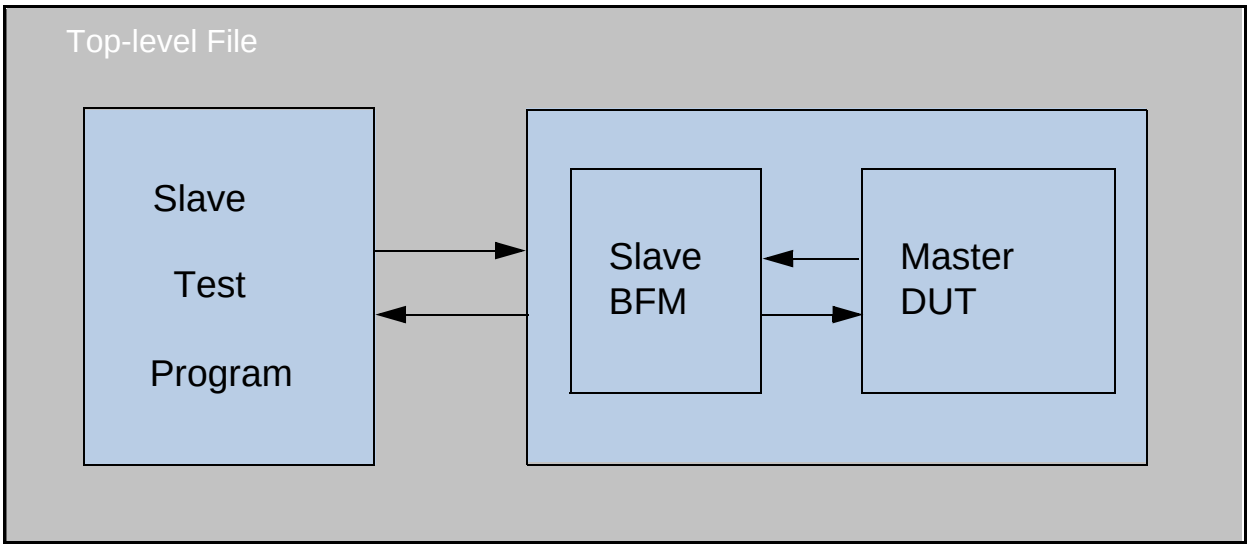
## handle_read_data_ready

The *handle read data ready* process handles the *RREADY* signal for the read data channel. It delays the assertion of the *RREADY* signal based on the setting of the *m_rd_data_phase_ready_delay* variable. The whole process runs concurrently with other processes in the test program, using the *path_id* = *AXI4_PATH_6* (see Overloaded Procedure Common Arguments for details of *path_id*), and is similar in operation to the *handle_write_resp_ready* procedure. Refer to the "VHDL AXI4 Master BFM Test Program" on page 698 for the complete *handle_read_data_ready* code listing.

# Verifying a Master DUT

A master DUT component is connected to a slave BFM at the signal-level. A slave test program, written at the transaction-level, generates stimulus via the slave BFM to verify the master DUT. Figure 11-2 illustrates a typical top-level testbench environment.

**Figure 11-2. Master DUT Top-level Testbench Environment**




In this example the slave test program is a simple memory model.

A top-level file instantiates and connects all the components required to test and monitor the DUT, and controls the system clock (*ACLK*) and reset (*ARESETn*) signals.

# AXI3 BFM Slave Test Program

The Slave Test Program is a memory model and contains two APIs: an "AXI3 Basic Slave API Definition" and an "AXI3 Advanced Slave API Definition".

The *AXI3 Basic Slave API Definition* allows you to create a wide range of stimulus scenarios to test a master DUT. This simple API design illustrates the creation of slave stimulus based on the default response of *OKAY* to master read and write transactions.

The *AXI3 Advanced Slave API Definition* allows you to create additional response scenarios to transactions. For example, a successful exclusive transaction requires an *EXOKAY* response.

For a complete code listing of the Slave Test Program APIs, refer to the "VHDL AXI3 Slave BFM Test Program" on page 692 in Appendix B.

# AXI3 Basic Slave API Definition

The Slave Test Program Basic API contains:

- Procedures that read and write a byte of data to *internal memory do_byte_read()* and *do_byte_write()*, respectively.
- Procedures to configure the AXI3 protocol channel handshake delays *set_read_address_ready_delay()*, set_write_address_ready_delay(), *set_write_data_ready_delay()*, *set_read_data_valid_delay()* and *set_wr_resp_valid_delay()*.
- Procedures to process read and write transactions, *process_read* and *process write*, respectively. If you need to create other responses, such as *EXOKAY*, *DECERR*, or *SLVERR*, then you must edit these procedures to provide the required response.
- A *slave_mode* transaction field to control the behavior of reading and writing to the internal memory.

The internal memory for the slave is defined as an array of 8-bits, so that each byte of data is stored as an address/data pair.

**Example 11-11. internal memory**

```
type memory_t is array (0 to 2**16-1) of std_logic_vector(7 downto 0);
shared variable mem : memory_t;
```

The *do_byte_read()* procedure, when called, reads a *data* byte from the internal memory *mem,* given an address location *addr*, as demonstrated in Example 11-12.

You can edit this procedure to modify the way the read data is extracted from the internal memory.

### Example 11-12. do_byte_read()

```
-- Procedure : do_byte_read
-- Procedure to provide read data byte from memory at particular input
-- address
procedure do_byte_read
(
      addr : in std_logic_vector(AXI_MAX_BIT_SIZE-1 downto 0);
      data : out std_logic_vector(7 downto 0)
) is
begin
      data := mem(to_integer(addr));
end do_byte_read;
```

The *do_byte_write()* procedure, when called, writes a *data* byte to the internal memory *mem,* given an address location *addr*, as Example 11-13 illustrates.

You can edit this procedure to modify the way the write data is stored in the internal memory.

### Example 11-13. do_byte_write()

```
-- Procedure : do_byte_write
-- Procedure to write data byte to memory at particular input address
procedure do_byte_write
(
      addr : in std_logic_vector(AXI_MAX_BIT_SIZE-1 downto 0);
      data : in std_logic_vector(7 downto 0)
) is
begin
      mem(to_integer(addr)) := data;
end do_byte_write;
```

The *set_read_address_ready_delay()* procedure has two prototypes, one for multiple process threads by providing the *path_id* argument. When called it configures the *ARREADY* handshake signal to be delayed by a number of *ACLK* cycles which extends the length of the read address phase. The starting point of the delay is determined by the configuration of the *delay_mode* operational transaction field (refer to *"AXI3 BFM Delay Mode"* on page 22 for details). Example 11-14 demonstrates setting the *ARREADY* signal delay by 4 *ACLK* cycles.

You can edit this procedure to change the *ARREADY* signal delay.

### Example 11-14. set_read_address_ready_delay()

```
-- Procedure : set_read_address_ready_delay
-- This is used to set read address phase ready delay to extend phase
procedure set_read_address_ready_delay
(
      id : integer; signal tr_if : inout axi_vhd_if_struct_t
) is
begin
      set_address_ready_delay(4, id, index, tr_if);
```

```
end set_read_address_ready_delay;

procedure set_read_address_ready_delay
(
      id : integer; path_id : in axi_path_t;
      signal tr_if : inout axi_vhd_if_struct_t
) is
begin
      set_address_ready_delay(4, id, index, path_id, tr_if);
end set_read_address_ready_delay;
```

The *set_write_address_ready_delay()* procedure has two prototypes, one for multiple process threads by providing the *path_id* argument. When called it configures the *AWREADY* handshake signal to be delayed by a number of *ACLK* cycles, which extends the length of the write address phase. The starting point of the delay is determined by the configuration of the *delay_mode* operational transaction field (refer to "AXI3 BFM Delay Mode" on page 22 for details). Example 11-15 demonstrates setting the *AWREADY* signal delay by 2 *ACLK* cycles.

You can edit this procedure to change the *AWREADY* signal delay.

**Example 11-15. set_write_address_ready_delay()**

```
-- Procedure : set_write_address_ready_delay
-- This is used to set write address phase ready delay to extend phase
procedure set_write_address_ready_delay
(
      id : integer; signal tr_if : inout axi_vhd_if_struct_t
) is
begin
      set_address_ready_delay(2, id, index, tr_if);
end set_write_address_ready_delay;

procedure set_write_address_ready_delay
(
      id : integer; path_id : in axi_path_t;
      signal tr_if : inout axi_vhd_if_struct_t
) is
begin
      set_address_ready_delay(2, id, index, path_id, tr_if);
end set_write_address_ready_delay;
```

The *set_write_data_ready_delay()* procedure has two prototypes, one for multiple process threads by providing the *path_id* argument. When called it configures the *WREADY* signal handshake to be delayed by a number of *ACLK* cycles which extends the length of each write data phase (beat) in a write data burst. The starting point of the delay is determined by the configuration of the *delay_mode* operational transaction field (refer to "AXI3 BFM Delay Mode" on page 22 for details).

For each write data phase (beat) the delay value of the *WREADY* signal is stored in an element of the *data_ready_delay[]* array for the transaction, as demonstrated in Example 11-16.

You can edit this procedure to change the *WREADY* signal delays.

### Example 11-16. set_write_data_ready_delay()

```
-- Procedure : set_write_data_ready_delay
-- This will set the ready delays for each write data phase in a write data
-- burst
procedure set_write_data_ready_delay
(
      id : integer;
      signal tr_if : inout axi_vhd_if_struct_t
) is
      variable burst_length : integer;
begin
    get_burst_length(burst_length, id, index, tr_if);
    for i in  0 to burst_length loop
      set_data_ready_delay(i, i, id, index, tr_if);
    end loop;
end set_write_data_ready_delay;

procedure set_write_data_ready_delay
(
      id : integer; path_id : in axi_path_t;
      signal tr_if : inout axi_vhd_if_struct_t
) is
    variable burst_length : integer;
begin
    get_burst_length(burst_length, id, index, path_id, tr_if);
    for i in  0 to burst_length loop
      set_data_ready_delay(i, i, id, index, path_id, tr_if);
    end loop;
end set_write_data_ready_delay;
```

The set_read_data_valid_delay() procedure has two prototypes, one for multiple process threads by providing the *path_id* argument. When called it configures the *RVALID* signal to be delayed by a number of *ACLK* cycles with the effect of delaying the start of each read data phase (beat) in a read data burst. The starting point of the delay is determined by the configuration of the *delay_mode* operational transaction field ("AXI3 BFM Delay Mode" on page 22 or details).

For each read data phase (beat) the delay value of the *RVALID* signal is stored in an element of the *data_valid_delay[]* array for the transaction, as demonstrated in Example 11-17.

You can edit this procedure to change the *RVALID* signals delays.

### Example 11-17. set_read_data_valid_delay()

```
-- Procedure : set_read_data_valid_delay
-- This will set the ready delays for each write data phase in a write data
-- burst
procedure set_read_data_valid_delay
(
      id : integer; signal tr_if : inout axi_vhd_if_struct_t
) is
    variable burst_length : integer;
begin
    get_burst_length(burst_length, id, index, tr_if);
    for i in  0 to burst_length loop
      set_data_valid_delay(i, i, id, index, tr_if);
    end loop;
end set_read_data_valid_delay;

procedure set_read_data_valid_delay
(
      id : integer; path_id : in axi_path_t;
      signal tr_if : inout axi_vhd_if_struct_t
) is
variable burst_length : integer;
begin
    get_burst_length(burst_length, id, index, path_id, tr_if);
    for i in  0 to burst_length loop
      set_data_valid_delay(i, i, id, index, path_id, tr_if);
    end loop;
end set_read_data_valid_delay;
```

The *set_wr_resp_valid_delay()* procedure has two prototypes, one for multiple process threads by providing the *path_id* argument. When called, it configures the *BREADY* signal handshake to be delayed by a number of *ACLK* cycles, which extends the length of the write response phase. The starting point of the delay is determined by the configuration of the *delay_mode* operational transaction field (refer to "AXI3 BFM Delay Mode" on page 22 for details). Example 11-18 demonstrates setting the *BREADY* signal delay by 2 *ACLK* cycles.

You can edit this procedure to change the *BREADY* signal delay.

### Example 11-18. set_wr_resp_valid_delay()

```
-- Procedure : set_wr_resp_valid_delay
-- This is used to set write response phase valid delay to start driving
-- write response phase after specified delay.
procedure set_wr_resp_valid_delay
(
      id : integer; signal tr_if : inout axi_vhd_if_struct_t
) is
begin
    set_write_response_valid_delay(0, id, index, tr_if);
end set_wr_resp_valid_delay;

procedure set_wr_resp_valid_delay
(
      id : integer; path_id : in axi_path_t;
      signal tr_if : inout axi_vhd_if_struct_t
) is
begin
    set_write_response_valid_delay(0, id, index, path_id, tr_if);
end set_wr_resp_valid_delay;
```

There is a *slave_mode* transaction field that you can configure to control the behavior of reading and writing to the *internal memory*. It has two modes: *AXI_TRANSACTION_SLAVE* and *AXI_PHASE_SLAVE* (refer to Example 11-19).

### Example 11-19. slave_mode

```
-- Slave mode type definition
type axi_slave_mode_e is (AXI_TRANSACTION_SLAVE, AXI_PHASE_SLAVE);

-- Slave mode selection : Default is transaction-level slave
signal slave_mode : axi_slave_mode_e := AXI_TRANSACTION_SLAVE;
```

The default *AXI_TRANSACTION_SLAVE* mode "saves up" an entire data burst and modifies the Slave Test Program's internal memory in zero time for the whole burst. Therefore, a read from internal memory is buffered at the beginning of the read burst for the whole burst. The buffered read data is then transmitted over the protocol signals to the master on a phase-by-phase (beat-by-beat) basis. For a write, the write data burst is buffered on a phase-by-phase (beat-by-beat) basis for the whole burst. Only at the end of the write burst are the buffered contents written to the internal memory.

The *AXI_PHASE_SLAVE* mode changes the Slave Test Program internal memory on each data phase (beat). Therefore, a read from the internal memory occurs only when the read data phase (beat) actually starts on the protocol signals. For a write, data is written to the internal memory as soon as each individual write data phase (beat) completes.

**Note**

In addition to the above procedures, you can configure other aspects of the AXI3 Slave BFM by using the procedures: "set_config()" on page 337 and "get_config()" on page 339.

## Using the AXI3 Basic Slave Test Program API

As described in the *AXI3 Basic Slave API Definition* section, there are a set of procedures that you use to create stimulus scenarios based on a memory-model slave with a minimal amount of editing. However, consider the following configurations when using the Slave Test program.

- *slave_mode* - the read and write channel interaction can cause simultaneous read and write transactions to occur at the same address. With the default *slave_mode* setting the read transaction, data burst is buffered at the start of the burst and the write data burst is buffered at the end of the burst. This can result in the read data being stale at the time it is transmitted over the protocol signals. If this is an undesirable result, then set the *slave_mode* to be *AXI_PHASE_SLAVE*.
- *delay_mode* - by default, the handshake **READY* signal always follows, or is simultaneous with the **VALID* signal. By configuring the *delay_mode* to be *AXI_TRANS2READY, *READY* before **VALID* scenarios can be achieved.

# AXI3 Advanced Slave API Definition

**Note**

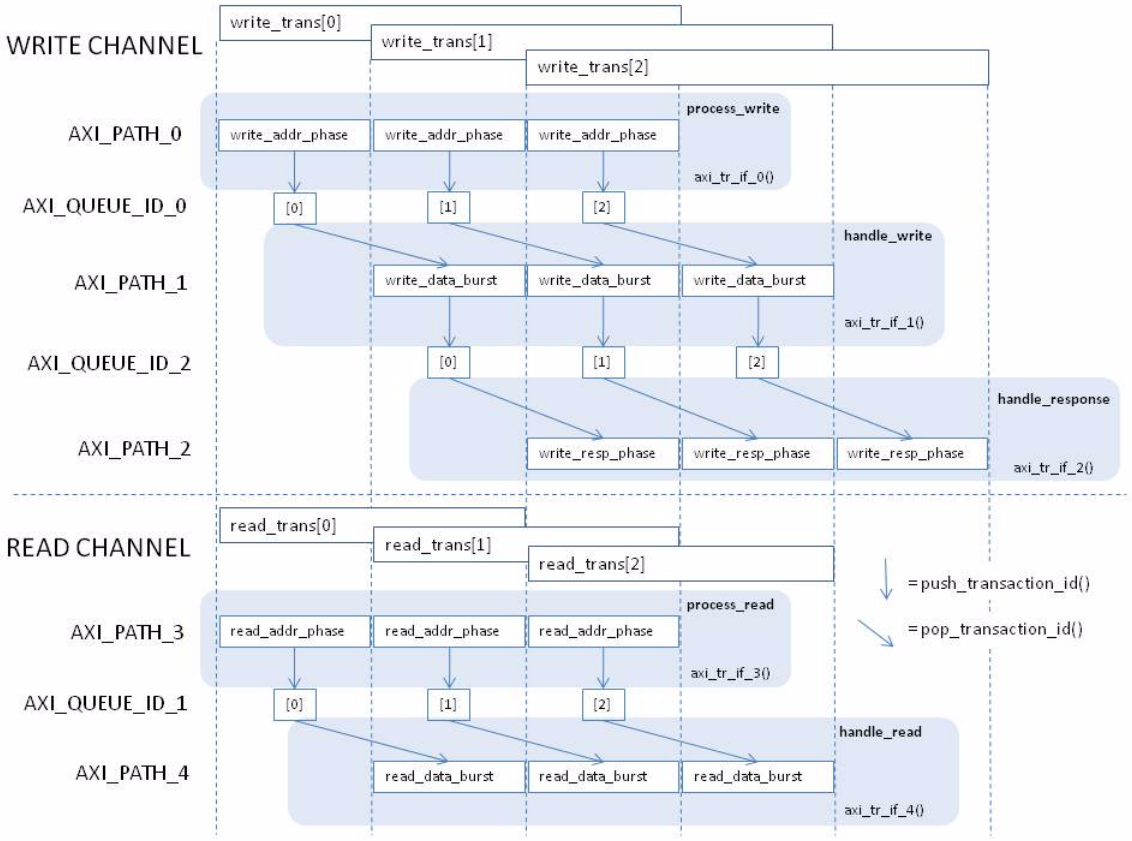
You are not required to edit the following Advance Slave API unless you require a different response than the default (*OKAY*) response.

The remaining section of this tutorial presents a walk-through of the Advanced Slave API. It consists of three processes for write transactions and two for read transactions. You are not required to edit the following Advance Slave API, unless you require a different response than the default (*OKAY*) response.

The Advanced Slave API is capable of handling pipelined transactions. Pipelining can occur when a transaction starts before a previous transaction has completed. Therefore, a write transaction that starts before a previous write transaction has completed can be pipelined. Figure 11-3 shows the write channel having three concurrent *write_trans* transactions, with the *write_addr_phase[2]*, *write_data_burst[1]* and *write_response_phase[0]* being concurrently active on the write address, data and response channels, respectively.

Similarly, a read transaction that starts before a previous read transaction has completed can be pipelined. Figure 11-3 shows the read channel having two concurrent *read_trans* transactions, whereby the *read_addr_phase[1]* and *read_data_burst[0]* are concurrently active on the read address and data channels, respectively.

**Figure 11-3. Slave Test Program Advanced API Tasks**




The *process write* code extract demonstrates how to create and process multiple write transactions. Each write transaction has a unique *transaction_id* number associated with it that increments for each new transaction. A *write_trans* variable is defined to hold this *transaction_id*.

The processing of write transactions begins an *ACLK* period after the *ARESETn* signal is inactive. A loop then creates a slave transaction for the BFM indexed by the *index* argument. In the loop, the delay for the *AWREADY* signal is set by the *set_write_address_ready_delay* procedure and then it waits for a write address phase to occur using the *get_write_addr_phase* procedure. The transaction record is then pushed onto a transaction queue with its unique *write_trans* transaction index and queue identifier *AXI_QUEUE_ID_0* by the *push_transaction_id* procedure.

The loop then completes and starts again by creating a new transaction and waiting for another write address phase to occur (refer to Example 11-20).

### Example 11-20. process write

```
-- process_write : write address phase through path 0
-- This process keep receiving write address phases and pushes
-- the transaction into a queue via the push_transaction_id procedure.
process
    variable write_trans : integer;
begin
   wait_on(AXI_RESET_POSEDGE, index, axi_tr_if_0(index));
   wait_on(AXI_CLOCK_POSEDGE, index, axi_tr_if_0(index));
   loop
      create_slave_transaction(write_trans, index, axi_tr_if_0(index));
      set_write_address_ready_delay(write_trans, axi_tr_if_0(index));
      get_write_addr_phase(write_trans, index, axi_tr_if_0(index));
      push_transaction_id(write_trans, AXI_QUEUE_ID_0, index,
axi_tr_if_0(index));
    end loop;
    wait;
end process;
```

The *handle_write* code extract demonstrates how to write a data burst to an internal memory using buffered and unbuffered approaches.

To perform pipelining of the AXI3 address and data phases of one transaction concurrently with another transaction, the Advanced Slave API provides procedures with an optional *path_id* argument. This permits multiple threads of code execution in the Slave API. The following *handle_write* code uses *path_id* = `AXI_PATH_1`, as an example.

Initially, a number of local variables are defined to hold the transaction index *write_trans* and some of the transaction fields, such as burst length, data, etc. In a loop, the existing record of the *write_trans* transaction is popped from the queue identifier *AXI_QUEUE_ID_0* via the *pop_transaction_id* procedure. The delay for the *WREADY* signal is then set by the *set_write_data_ready_delay* procedure.

If the *slave_mode* is configured to *AXI_TRANSACTION_SLAVE* (buffered) the code waits for a complete write data burst by the *get_write_data_burst* procedure before continuing. The burst length of the write data burst is obtained using the *get_burst_length* procedure. The resulting *burst_length* is then used to set the subsequent maximum inner loop *i* count for the number of data beats in the burst. Loop *i* gets the address and data pairs from the transaction via the *get_write_addr_data* procedure before calling the *do_byte_write* procedure which writes the *data* byte into the memory *mem* at the corresponding *addr* address. If the number of bytes to be written (for this beat) is more than one, then loop *j* writes the remaining bytes of this beat into the memory *mem*. Loop *i* then repeats for each data beat up to the length of the data burst.

If the *slave_mode* is configured to *AXI_PHASE_SLAVE* (unbuffered) the code waits for a single write data phase (beat) to complete via the *get_write_data_phase* procedure, in a *while* loop. The address and data pairs from the transaction are obtained by the *get_write_addr_data* procedure before calling the *do_byte_write* procedure which writes the *data* byte into the memory *mem* at the corresponding *addr* address. If the number of bytes to be written (for this

beat) is more than one, then loop *j* writes the remaining bytes of this beat into the memory *mem*. The *while* loop then repeats, waiting for another data phase (beat), if this is not the last data phase (beat) in the burst.

The transaction record, so far, is then pushed onto a new transaction queue identifier *AXI_QUEUE_ID_2* by the *push_transaction_id* procedure, which is then ready for the slave to execute a response back to the master (refer to Example 11-21).

### Example 11-21. handle_write

```
-- handle_write : write data phase through path 1
-- This process receives write data burst, or write phases (beats).
-- The slave_mode configuration controls when the write data is passed to
-- memory.
  process
    variable write_trans: integer;
    variable byte_length : integer;
    variable burst_length : integer;
    variable addr : std_logic_vector(AXI_MAX_BIT_SIZE-1 downto 0);
    variable data : std_logic_vector(7 downto 0);
    variable last : integer := 0;
    variable loop_i : integer := 0;
  begin
    loop
      pop_transaction_id(write_trans, AXI_QUEUE_ID_0, index, AXI_PATH_1,
axi_tr_if_1(index));
      set_write_data_ready_delay(write_trans, AXI_PATH_1,
axi_tr_if_1(index));

      if (slave_mode = AXI_TRANSACTION_SLAVE) then
        get_write_data_burst(write_trans, index, AXI_PATH_1,
axi_tr_if_1(index));
        get_burst_length(burst_length, write_trans, index, AXI_PATH_1,
axi_tr_if_1(index));
        for i in  0 to burst_length loop
         get_write_addr_data(write_trans,  i, 0, byte_length, addr, data,
index, AXI_PATH_1, axi_tr_if_1(index));
          do_byte_write(addr, data);
          if byte_length > 1 then
            for j in 1 to byte_length-1 loop
               get_write_addr_data(write_trans,  i, j, byte_length, addr,
data, index, AXI_PATH_1, axi_tr_if_1(index));
              do_byte_write(addr, data);
            end loop;
          end if;
        end loop;
      else
        last := 0;
        loop_i := 0;
        while(last = 0) loop
          get_write_data_phase(write_trans, loop_i, last, index,
AXI_PATH_1, axi_tr_if_1(index));
get_write_addr_data(write_trans,  loop_i, 0, byte_length, addr, data,
index, AXI_PATH_1, axi_tr_if_1(index));
          do_byte_write(addr, data);
```

```
          if byte_length > 1 then
            for j in 1 to byte_length-1 loop
               get_write_addr_data(write_trans,  loop_i, j, byte_length,
addr, data, index, AXI_PATH_1, axi_tr_if_1(index));
               do_byte_write(addr, data);
            end loop;
          end if;
            loop_i := loop_i + 1;
        end loop;
      end if;
      push_transaction_id(write_trans, AXI_QUEUE_ID_2, index, AXI_PATH_1,
axi_tr_if_1(index));
    end loop;
    wait;
  end process;
```

The *handle_response* code extract demonstrates how to respond to a master write transaction using a different *path_id = AXI_PATH_2* than the path_id used for the address and data phases of the same transaction. This gives the ability for the slave to execute a write transaction response in a different order than the order received for a particular *write_trans* index number.

A *write_trans* variable is defined to hold this transaction index number before entering a loop to pop a write transaction from *AXI_QUEUE_ID_2* via the *pop_transaction_id* procedure call. The delay for the *BVALID* signal is then set via the *set_wr_resp_valid_delay* procedure. The response phase is then executed by the *execute_write_response_phase* procedure call (refer to Example 11-22).

### Example 11-22. handle_response

```
-- handle_response : write response phase through path 2
-- This method sends the write response phase
process
    variable write_trans: integer;
  begin
    loop
      pop_transaction_id(write_trans, AXI_QUEUE_ID_2, index, AXI_PATH_2,
axi_tr_if_2(index));
      set_wr_resp_valid_delay(write_trans, AXI_PATH_2,
axi_tr_if_2(index));
      execute_write_response_phase(write_trans, index, AXI_PATH_2,
axi_tr_if_2(index));
    end loop;
    wait;
  end process;
```

The processing of read transactions works in a similar way as that described above for write transactions. There are two processes *process_read* and *handle read*.

The main difference between write and read transaction handling is that the read transaction retrieves the read data burst from the internal memory *mem* at the start of the data burst, or on a phase-by-phase (beat-by-beat) basis, depending on the *slave_mode* configuration setting. In addition AXI3 has a read response per read data phase (beat), so unlike the write, read does not require a separate read response handling process (refer to Example 11-23 and Example 11-24).

### Example 11-23. process_read

```
-- process_read : read address phase through path 3
  -- This process keep receiving read address phase and push the
transaction into queue through
  -- push_transaction_id API.
  process
    variable read_trans: integer;
  begin
   wait_on(AXI_RESET_POSEDGE, index, AXI_PATH_3, axi_tr_if_3(index));
   wait_on(AXI_CLOCK_POSEDGE, index, AXI_PATH_3, axi_tr_if_3(index));
      loop
      create_slave_transaction(read_trans, index, AXI_PATH_3,
axi_tr_if_3(index));
      set_read_address_ready_delay(read_trans, AXI_PATH_3,
axi_tr_if_3(index));
      get_read_addr_phase(read_trans, index, AXI_PATH_3,
axi_tr_if_3(index));
      push_transaction_id(read_trans, AXI_QUEUE_ID_1, index, AXI_PATH_3,
axi_tr_if_3(index));
    end loop;
    wait;
  end process;
```

## Example 11-24. handle read

```
-- handle_read : read data and response through path 4
  -- This process reads data from memory and send read data/response
either at
  -- burst or phase level depending upon slave working mode.
  process
    variable read_trans: integer;
    variable burst_length : integer;
    variable byte_length : integer;
    variable addr : std_logic_vector(AXI_MAX_BIT_SIZE-1 downto 0);
    variable data : std_logic_vector(7 downto 0);
  begin
    loop
      pop_transaction_id(read_trans, AXI_QUEUE_ID_1, index, AXI_PATH_4,
axi_tr_if_4(index));
      set_read_data_valid_delay(read_trans, AXI_PATH_4,
axi_tr_if_4(index));
      get_burst_length(burst_length, read_trans, index, AXI_PATH_4,
axi_tr_if_4(index));
      for i in  0 to burst_length loop
        get_read_addr(read_trans,  i, 0, byte_length, addr, index,
AXI_PATH_4, axi_tr_if_4(index));
        do_byte_read(addr, data);
        set_read_data(read_trans, i, 0, byte_length, addr, data, index,
AXI_PATH_4, axi_tr_if_4(index));
         if byte_length > 1 then
          for j in 1 to byte_length-1 loop
             get_read_addr(read_trans,  i, j, byte_length, addr, index,
AXI_PATH_4, axi_tr_if_4(index));
             do_byte_read(addr, data);
             set_read_data(read_trans, i, j, byte_length, addr, data,
index, AXI_PATH_4, axi_tr_if_4(index));
            end loop;
        end if;
         if slave_mode = AXI_PHASE_SLAVE then
            execute_read_data_phase(read_trans, i, index, AXI_PATH_4,
axi_tr_if_4(index));
         end if;
      end loop;
      if slave_mode = AXI_TRANSACTION_SLAVE then
        execute_read_data_burst(read_trans, index, AXI_PATH_4,
axi_tr_if_4(index));
      end if;
    end loop;
    wait;
  end process;
```

# AXI4 BFM Slave Test Program

The Slave Test Program is a memory model that contains two APIs: an AXI4 Basic Slave API Definition and an AXI4 Advanced Slave API Definition.

The AXI4 Basic Slave API Definition allows you to create a wide range of stimulus scenarios to test a master DUT. This API definition simplifies the creation of slave stimulus based on the default response of *OKAY* to master read and write transactions.

The AXI4 Advanced Slave API Definition allows you to create additional response scenarios to transactions. For example, a successful exclusive transaction requires an *EXOKAY* response.

For a complete code listing of the slave test program refer to "SystemVerilog AXI4 Slave BFM Test Program" on page 682.

## AXI4 Basic Slave API Definition

The Basic Slave Test Program API contains:

- Procedures *do_byte_read()* and *do_byte_write()* that read and write a byte of data to Internal Memory*set_wr_resp_valid_delay()*, respectively.
- Procedures *set_read_data_valid_delay()* and *set_wr_resp_valid_delay()* to configure the delay of the read data channel *RVALID*, and write response channel *BVALID* signals, respectively.
- Variables *m_wr_addr_phase_ready_delay* and *m_rd_addr_phase_ready_delay* to configure the delay of the read/write address channel *AWVALID/ARVALID* signals, and *m_wr_data_phase_ready_delay* to configure the delay of the write response channel *BVALID* signal
- A *slave_mode* variable to configure the behavior of reading and writing to the internal memory.

### Internal Memory

The internal memory for the slave is defined as an array of 8-bits, so that each byte of data is stored as an address/data pair.

**Example 11-25. Internal Memory**

```
type memory_t is array (0 to 2**16-1) of std_logic_vector(7 downto 0);
shared variable mem : memory_t;
```

## do_byte_read()

The *do_byte_read()* procedure reads a *data* byte from the Internal Memory *mem* given an address location *addr*, as shown below.

You can edit this procedure to modify the way the read data is extracted from the internal memory.

```
-- Procedure : do_byte_read
-- Procedure to provide read data byte from memory at particular input
-- address
procedure do_byte_read(addr : in std_logic_vector(AXI4_MAX_BIT_SIZE-1
downto 0); data : out std_logic_vector(7 downto 0)) is
begin
   data := mem(to_integer(addr));
end do_byte_read;
```

## do_byte_write()

The *do_byte_write()* procedure when called writes a *data* byte to the Internal Memory *mem* given an address location *addr*, as shown below.

You can edit this procedure to modify the way the write data is stored in the internal memory.

```
-- Procedure : do_byte_write
-- Procedure to write data byte to memory at particular input address
procedure do_byte_write(addr : in std_logic_vector(AXI4_MAX_BIT_SIZE-1
downto 0);  data : in std_logic_vector(7 downto 0)) is
begin
   mem(to_integer(addr)) := data;
end do_byte_write;
```

## m_wr_addr_phase_ready_delay

The *m_wr_addr_phase_ready_delay* variable holds the *AWREADY* signal delay. The delay value extends the length of the write address phase by a number of *ACLK* cycles. The starting point of the delay is determined by the assertion of the *AWVALID* signal.

Example 11-26 shows the *AWREADY* signal delayed by 2 *ACLK* cycles. You can edit this variable to change the *AWREADY* signal delay.

**Example 11-26. m_wr_addr_phase_ready_delay**

```
-- Variable : m_wr_addr_phase_ready_delay
signal m_wr_addr_phase_ready_delay : integer := 2;
```

## m_rd_addr_phase_ready_delay

The *m_rd_addr_phase_ready_delay* variable holds the *ARREADY* signal delay. The delay value extends the length of the read address phase by a number of *ACLK* cycles. The starting point of the delay is determined by the assertion of the *ARVALID* signal.

Example 11-27 shows the *ARREADY* signal delayed by 2 *ACLK* cycles. You can edit this variable to change the *ARREADY* signal delay.

**Example 11-27. m_rd_addr_phase_ready_delay**

```
-- Variable : m_rd_addr_phase_ready_delay
signal m_rd_addr_phase_ready_delay : integer := 2;
```

## m_wr_data_phase_ready_delay

The *m_wr_data_phase_ready_delay* variable holds the *WREADY* signal delay. The delay value extends the length of each write data phase (beat) in a write data burst by a number of *ACLK* cycles. The starting point of the delay is determined by the assertion of the *WVALID* signal.

Example 11-28 shows the *WREADY* signal delayed by 2 *ACLK* cycles. You can edit this function to change the *WREADY* signal delay.

**Example 11-28. m_wr_data_phase_ready_delay**

```
-- Variable : m_wr_data_phase_ready_delay
signal m_wr_data_phase_ready_delay : integer := 2;
```

## set_wr_resp_valid_delay()

The *set_wr_resp_valid_delay()* procedure has two prototypes (*path_id* is optional), and configures the *BVALID* signal to be delayed by a number of *ACLK* cycles with the effect of delaying the start of the write response phase. The delay value of the *BVALID* signal is stored in the *write_response_valid_delay* transaction field.

Example 11-29 shows the *BVALID* signal delay set to 2 *ACLK* cycles. You can edit this function to change the *BVALID* signal delay.

**Example 11-29. set_wr_resp_valid_delay()**

```
-- Procedure : set_wr_resp_valid_delay
-- This is used to set write response phase valid delay to start driving
-- write response phase after specified delay.
procedure set_wr_resp_valid_delay(id : integer; path_id : in axi4_path_t;
signal tr_if : inout axi4_vhd_if_struct_t) is
begin
   set_write_response_valid_delay(2, id, index, path_id, tr_if);
end set_wr_resp_valid_delay;
```

## set_read_data_valid_delay()

The *set_read_data_valid_delay()* procedure has two prototypes (*path_id* is optional), and configures the *RVALID* signal to be delayed by a number of *ACLK* cycles with the effect of delaying the start of a read data phase (beat) in a read data burst. The delay value of the *RVALID* signal, for each read data phase, is stored in an array element of the *data_valid_delay* transaction field.

Example 11-30 shows the *RVALID* signal delay incrementing by an *ACLK* cycle between each read data phase for the length of the burst. You can edit this function to change the *RVALID* signal delay for the whole read burst.

**Example 11-30. set_read_data_valid_delay()**

```
procedure set_read_data_valid_delay(id : integer; path_id : in
axi4_path_t; signal tr_if : inout axi4_vhd_if_struct_t) is
   variable burst_length : integer;
begin
   get_burst_length(burst_length, id, index, path_id, tr_if);
   for i in  0 to burst_length loop
      set_data_valid_delay(i, i, id, index, path_id, tr_if);
   end loop;
end set_read_data_valid_delay;
```

## slave_mode

A configurable *slave_mode* signal controls the behavior of reading and writing to the Internal Memory. It has two modes *AXI4_TRANSACTION_SLAVE* and *AXI4_PHASE_SLAVE*, as shown below.

```
type axi4_slave_mode_e is (AXI4_TRANSACTION_SLAVE, AXI4_PHASE_SLAVE);

...

-- Slave mode seclection : default it is transaction level slave
signal slave_mode : axi4_slave_mode_e := AXI4_TRANSACTION_SLAVE;
```

The default *AXI4_TRANSACTION_SLAVE* mode “saves up” an entire data burst and modifies the slave test program internal memory in zero time for the whole burst. Therefore, a burst read from internal memory is buffered from the beginning of the burst to the end of the burst. The buffered read burst data is then transmitted over the protocol signals to the master on a phase-by-phase (beat-by-beat) basis. For a write, the data burst received over the protocol signals is buffered from the beginning of the burst to the end of the burst. At the end of the write burst the buffered contents are written to the internal memory.

The *AXI4_PHASE_SLAVE* mode updates the slave test program internal memory on each data phase (beat). Therefore, a read from the internal memory occurs only when the read data phase (beat) actually starts to be transmitted on the protocol signals. For a write, data is written to the internal memory as soon as each individual write data phase (beat) is received on the protocol signals.

**Note**

In addition to the above variables and procedures, you can configure other aspects of the AXI4 Slave BFM by using the procedures: *"set_config()"* on page 337 and *"get_config()"* on page 339.

## Using the AXI4 Basic Slave Test Program API

There are a set of variables and procedures that you can use to create stimulus scenarios based on a memory-model slave with a minimal amount of editing, as described in the AXI4 Basic Slave API Definition section.

Consider the following configuration when using the slave test program.

In *slave_mode*, the read and write channel interaction can cause simultaneous read and write transactions to occur at the same address. With the default *slave_mode* setting the read transaction data burst is buffered at the start of the burst and the write data burst is buffered at the end of the burst. This can result in the read data being stale at the time it is transmitted over the protocol signals. If this is an undesirable feature, then set the *slave_mode* to be *AXI4_PHASE_SLAVE*.

## AXI4 Advanced Slave API Definition

**Note**

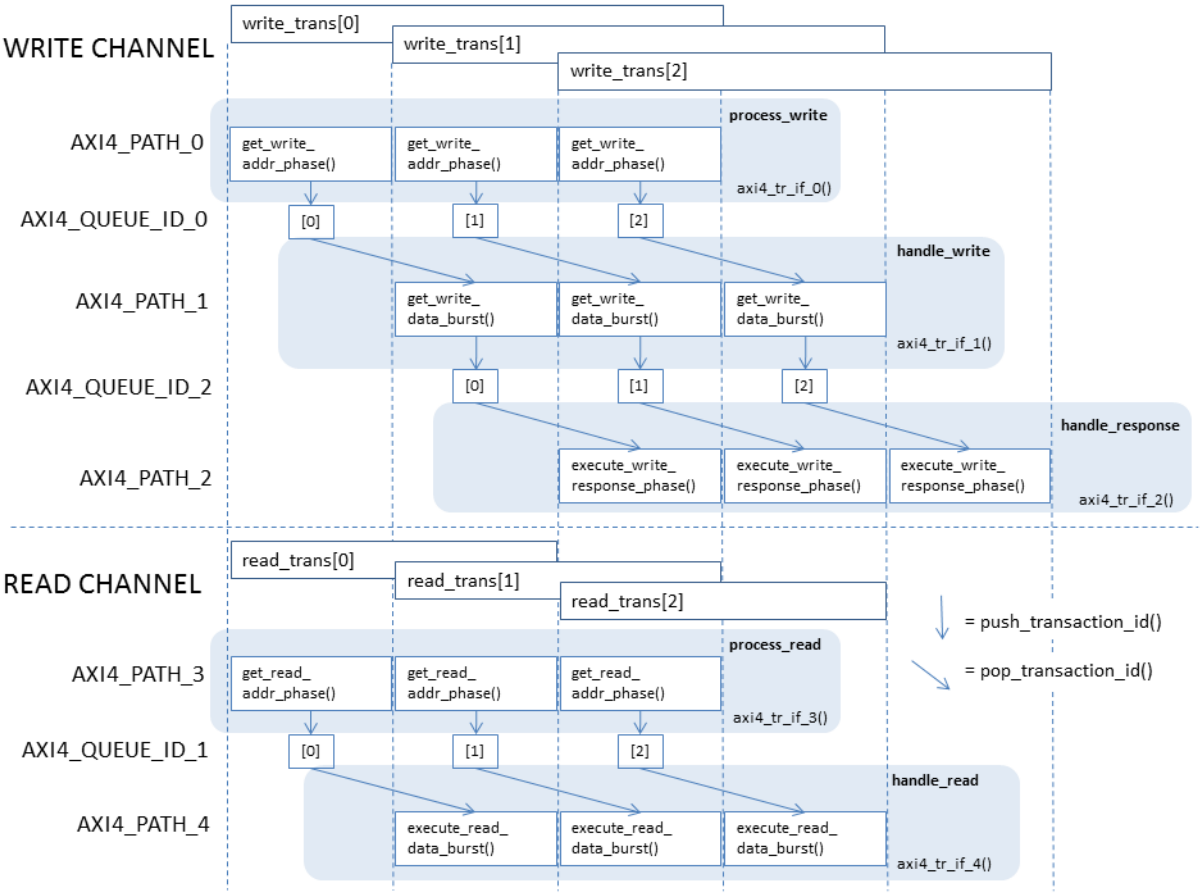
You are not required to edit the following Advance Slave API unless you require a different response than the default (*OKAY*) response.

The remaining section of this tutorial presents a walk-through of the Advanced Slave API in the slave test program. It consists of five main processes, *process_write*, *process_read*, *handle_write, handle_response*. and *handle_write* in the slave test program, as shown in Figure 11-4. There are additional *handle_write_addr_ready*, *handle_read_addr_ready* and *handle_write_data_ready* processes to handle the handshake *AWREADY*, *ARREADY* and *WREADY* signals, respectively.

The Advanced Slave API is capable of handling pipelined transactions. Pipelining can occur when a transaction starts before a previous transaction has completed. Therefore, a write transaction that starts before a previous write transaction has completed can be pipelined. Figure 11-4 shows the write channel having three concurrent *write_trans* transactions, whereby the *get_write_addr_phase[2]*, *get_write_data_burst[1]* and *execute_write_response_phase[0]* are concurrently active on the write address, data and response channels, respectively.

Similarly, a read transaction that starts before a previous read transaction has completed can be pipelined. Figure 11-4 shows the read channel having two concurrent *read_trans* transactions, whereby the *get_read_addr_phase[1]* and *execute_read_data_burst[0]* are concurrently active on the read address and data channels, respectively.

**Figure 11-4. Slave Test Program Advanced API Processes**




## process_read

The *process_read* process creates a slave transaction and receives the read address phase. It uses unique path and queue identifiers to work concurrently with other processes.

The processing of read transactions begins an *ACLK* period after the *ARESETn* signal is inactive, as shown in Example 11-31.

Each slave transaction has a unique *transaction_id* number associated with it that is automatically incremented for each new slave transaction created. In a *loop* the *create_slave_transaction()* procedure call returns the *transaction_id* for the slave BFM.indexed by the *index* argument. A *read_trans* variable is previously defined to hold the *transaction_id*.

A call to the *get_read_addr_phase()* procedure blocks the code until a read address phase has completed. The call to the *push_transaction_id()* procedure pushes *read_trans* into the *AXI4_QUEUE_ID_1* queue.

The *loop* completes and restarts by creating a new slave transaction and blocks for another write address phase to occur.

**Example 11-31. process_read**

```
-- process_read : read address phase through path 3
-- This process keep receiving read address phase and push
-- the transaction into queue through push_transaction_id API.
process
   variable read_trans: integer;
begin
   wait_on(AXI4_RESET_POSEDGE, index, AXI4_PATH_3, axi4_tr_if_3(index));
   wait_on(AXI4_CLOCK_POSEDGE, index, AXI4_PATH_3, axi4_tr_if_3(index));
   loop
      create_slave_transaction(read_trans, index, AXI4_PATH_3,
axi4_tr_if_3(index));
      get_read_addr_phase(read_trans, index, AXI4_PATH_3,
axi4_tr_if_3(index));
      push_transaction_id(read_trans, AXI4_QUEUE_ID_1, index,
AXI4_PATH_3, axi4_tr_if_3(index));
   end loop;
   wait;
end process;
```

## handle_read

The *handle_read* process gets read data from the Internal Memory as a burst or phase (beat), depending on the *slave_mode* configuration. It uses unique path and queue identifiers to work concurrently with other processes.

In a *loop,* the *pop_transaction_id()* procedure call returns the *transaction_id* from the queue for the slave BFM.indexed by the *index* argument, as shown in Example 11-32below. A *read_trans* variable is previously defined to hold the *transaction_id*. If the queue is empty then *pop_transaction_id()* will block until content is available.

The call to *set_read_data_valid_delay()* configures the *RVALID* signal delay for each phase (beat) of the burst, and *get_burst_length()* returns the *burst_length* of the read transaction.

In a *loop,* the call to the *get_read_addr()* helper procedure returns the actual address *addr* for a particular byte location and the *byte_length* of the data phase (beat). This byte address is used to read the data byte from Internal Memory with the call to *do_byte_read()*, and the *set_read_data()* helper procedure sets the byte in the read transaction record. If the returned *byte_length>1* then the code performs in the *byte_length* loop the reading and setting of the read data from internal memory for the whole of the read data phase (beat).

If the *slave_mode* configuration is set to the default of *AXI4_TRANSACTION_SLAVE* then the *burst_length* loop continues until the read data has been set for the whole burst. Otherwise the individual read data phase is executed over the protocol signals by calling the *execute_read_data_phase()*.

After the *burst_length* loop is complete, *execute_read_data_burst()* is called for the default configuration of *slave_mode* and the read burst is executed over the protocol signals.

The loop completes and restarts by waiting for another *transaction_id* to be placed into the queue.

### Example 11-32. handle_read

```
-- handle_read : read data and response through path 4
-- This process reads data from memory and send read data/response either
-- at burst or phase level depending upon slave working mode.
process
   variable read_trans: integer;
   variable burst_length : integer;
   variable byte_length : integer;
   variable addr : std_logic_vector(AXI4_MAX_BIT_SIZE-1 downto 0);
   variable data : std_logic_vector(7 downto 0);
begin
   loop
      pop_transaction_id(read_trans, AXI4_QUEUE_ID_1, index, AXI4_PATH_4,
axi4_tr_if_4(index));
      set_read_data_valid_delay(read_trans, AXI4_PATH_4,
axi4_tr_if_4(index));

      get_burst_length(burst_length, read_trans, index, AXI4_PATH_4,
axi4_tr_if_4(index));
      for i in  0 to burst_length loop
         get_read_addr(read_trans,  i, 0, byte_length, addr, index,
AXI4_PATH_4, axi4_tr_if_4(index));
         do_byte_read(addr, data);
         set_read_data(read_trans, i, 0, byte_length, addr, data, index,
AXI4_PATH_4, axi4_tr_if_4(index));
         if byte_length > 1 then
            for j in 1 to byte_length-1 loop
               get_read_addr(read_trans,  i, j, byte_length, addr, index,
AXI4_PATH_4, axi4_tr_if_4(index));
               do_byte_read(addr, data);
               set_read_data(read_trans, i, j, byte_length, addr, data,
index, AXI4_PATH_4, axi4_tr_if_4(index));
            end loop;
         end if;
         if slave_mode = AXI4_PHASE_SLAVE then
            execute_read_data_phase(read_trans, i, index, AXI4_PATH_4,
axi4_tr_if_4(index));
         end if;
      end loop;
      if slave_mode = AXI4_TRANSACTION_SLAVE then
         execute_read_data_burst(read_trans, index, AXI4_PATH_4,
axi4_tr_if_4(index));
      end if;
   end loop;
   wait;
end process;
```

## process_write

The *process_write* process works in a similar way as that previously described for *process_read*. It uses unique path and queue identifiers to work concurrently with other processes, as shown in Example 11-33.

**Example 11-33. process_write**

```
-- process_write : write address phase through path 0
-- This process keep receiving write address phase and push the
-- transaction into queue through push_transaction_id API.
process
   variable write_trans : integer;
begin
   wait_on(AXI4_RESET_POSEDGE, index, axi4_tr_if_0(index));
   wait_on(AXI4_CLOCK_POSEDGE, index, axi4_tr_if_0(index));
   loop
      create_slave_transaction(write_trans, index, axi4_tr_if_0(index));
      get_write_addr_phase(write_trans, index, axi4_tr_if_0(index));
      push_transaction_id(write_trans, AXI4_QUEUE_ID_0, index,
axi4_tr_if_0(index));
   end loop;
   wait;
end process;
```

## handle_write

The handle_write process works in a similar way to that previously described for *handle_read*. The main difference is that the write transaction handling gets the write data and stores it in the slave test program Internal Memory depending on the *slave_mode* setting, and adhering to the state of the *WSTRB* write strobes signals. There is an additional *pop_transaction_id()* into a queue so that the *handle_response* process can send write response phase for the transaction, as shown in Example 11-34 below.

**Example 11-34. handle_write**

```
-- handle_write : write data phase through path 1
-- This method receive write data burst or phases for write transaction
-- depending upon slave working mode and write data to memory.
process
   variable write_trans: integer;
   variable byte_length : integer;
   variable burst_length : integer;
   variable addr : std_logic_vector(AXI4_MAX_BIT_SIZE-1 downto 0);
variable data : std_logic_vector(7 downto 0);
   variable last : integer := 0;
   variable loop_i : integer := 0;
begin
   loop
      pop_transaction_id(write_trans, AXI4_QUEUE_ID_0, index,
AXI4_PATH_1, axi4_tr_if_1(index));

      if (slave_mode = AXI4_TRANSACTION_SLAVE) then
         get_write_data_burst(write_trans, index, AXI4_PATH_1,
axi4_tr_if_1(index));
         get_burst_length(burst_length, write_trans, index, AXI4_PATH_1,
axi4_tr_if_1(index));
         for i in  0 to burst_length loop
            get_write_addr_data(write_trans,  i, 0, byte_length, addr,
data, index, AXI4_PATH_1, axi4_tr_if_1(index));
            do_byte_write(addr, data);
            if byte_length > 1 then
               for j in 1 to byte_length-1 loop
                  get_write_addr_data(write_trans,  i, j, byte_length,
addr, data, index, AXI4_PATH_1, axi4_tr_if_1(index));
                  do_byte_write(addr, data);
               end loop;
            end if;
         end loop;
      else
         last := 0;
         loop_i := 0;
         while(last = 0) loop
            get_write_data_phase(write_trans, loop_i, last, index,
AXI4_PATH_1, axi4_tr_if_1(index));
            get_write_addr_data(write_trans,  loop_i, 0, byte_length,
addr, data, index, AXI4_PATH_1, axi4_tr_if_1(index));
            do_byte_write(addr, data);
            if byte_length > 1 then
               for j in 1 to byte_length-1 loop
```

```
                  get_write_addr_data(write_trans,  loop_i, j,
byte_length, addr, data, index, AXI4_PATH_1, axi4_tr_if_1(index));
                  do_byte_write(addr, data);
               end loop;
            end if;
            loop_i := loop_i + 1;
         end loop;
      end if;
      push_transaction_id(write_trans, AXI4_QUEUE_ID_2, index,
AXI4_PATH_1, axi4_tr_if_1(index));
   end loop;
   wait;
end process;
```

## handle_response

The *handle_response* process sends a response back to the master to complete a write transaction. It uses unique path and queue identifiers to work concurrently with other processes.

In a *loop,* the *pop_transaction_id()* procedure call returns the *transaction_id* from the queue for the slave BFM.indexed by the *index* argument, as shown in Example 11-35 below. A *write_trans* variable is previously defined to hold the *transaction_id*. If the queue is empty then *push_transaction_id()* will block until content is available.

The call to *set_wr_resp_valid_delay()* sets the *BVALID* signal delay for the response prior to calling *execute_write_response_phase()* to execute the response over the protocol signals.

**Example 11-35. handle_response**

```
-- handle_response : write response phase through path 2
-- This method sends the write response phase
process
   variable write_trans: integer;
   begin
      loop
         pop_transaction_id(write_trans, AXI4_QUEUE_ID_2, index,
AXI4_PATH_2, axi4_tr_if_2(index));
         set_wr_resp_valid_delay(write_trans, AXI4_PATH_2,
axi4_tr_if_2(index));
         execute_write_response_phase(write_trans, index, AXI4_PATH_2,
axi4_tr_if_2(index));
   end loop;
   wait;
end process;
```

## handle_write_addr_ready

The *handle_write_addr_ready* process handles the *AWREADY* signal for the write address channel. It uses a unique path identifier to work concurrently with other processes.

The handling of the *AWREADY* signal begins an *ACLK* period after the *ARESETn* signal is inactive, as shown in Example 11-36 below. In a *loop,* the *AWREADY* signal is deasserted using the nonblocking call to the *execute_write_addr_ready()* procedure and blocks for a write channel address phase to occur with a call to the blocking *get_write_addr_cycle()* procedure. A received write address phase indicates that the *AWVALID* signal has been asserted, triggering the starting point for the delay of the *AWREADY* signal by the number of *ACLK* cycles defined by *m_wr_addr_phase_ready_delay*. Another call to the *execute_write_addr_ready()* procedure to assert the *AWREADY* signal completes the *AWREADY* handling.

**Example 11-36. handle_write_addr_ready**

```
-- handle_write_addr_ready : write address ready through path 5
-- This method assert/de-assert the write address channel ready signal.
-- Assertion and de-assertion is done based on m_wr_addr_phase_ready_delay
process
   variable tmp_ready_delay : integer;
begin
   wait_on(AXI4_RESET_POSEDGE, index, AXI4_PATH_5, axi4_tr_if_5(index));
   wait_on(AXI4_CLOCK_POSEDGE, index, AXI4_PATH_5, axi4_tr_if_5(index));
   loop
      wait until m_wr_addr_phase_ready_delay > 0;
      tmp_ready_delay := m_wr_addr_phase_ready_delay;
      execute_write_addr_ready(0, 1, index, AXI4_PATH_5,
axi4_tr_if_5(index));
      get_write_addr_cycle(index, AXI4_PATH_5, axi4_tr_if_5(index));
      if(tmp_ready_delay > 1) then
         for i in  0 to tmp_ready_delay-2 loop
            wait_on(AXI4_CLOCK_POSEDGE, index, AXI4_PATH_5,
axi4_tr_if_5(index));
         end loop;
      end if;
      execute_write_addr_ready(1, 1, index, AXI4_PATH_5,
axi4_tr_if_5(index));
   end loop;
   wait;
end process;
```

## handle_read_addr_ready

The *handle_read_addr_ready* process handles the *ARREADY* signal for the read address channel. It uses a unique path identifier to work concurrently with other processes. The *handle_read_addr_ready* process code works in a similar way to that previously described for the *handle_write_addr_ready* process. Refer to the "VHDL AXI4 Master BFM Test Program" on page 698 for the complete *handle_read_addr_ready* code listing.

## handle_write_data_ready

The *handle_write_data_ready* process handles the *WREADY* signal for the write data channel. It uses a unique path identifier to work concurrently with other processes.

The *handle_write_data_ready* process code works in a similar way to that previously described for the *handle_write_addr_ready* process. Refer to the "VHDL AXI4 Master BFM Test Program" on page 698 for the complete *handle_write_data_ready* code listing.

# Chapter 12
# Getting Started with Qsys and the BFMs

This example shows you how to use the Qsys tool in Quartus II software to create a top-level design environment. You will use the *ex1_back_to_back_sv*, a SystemVerilog example from the *$QUARTUS_ROOTDIR/../ip/altera/mentor_vip_ae/axi3/qsys-examples* directory in the Altera Complete Design Suite (ACDS) installation.

You will do the following tasks to set up the design environment:

1. Create a work directory
2. Copy the example to the work directory
3. Invoke Qsys from the Quartus II software Tools menu
4. Generate a top-level netlist
5. Run simulation by referencing the README and scripts for your simulation environment

## Setting Up Simulation from a UNIX Platform

The following steps outline how to set up the simulation environment from a UNIX platform.

1. Create a work directory into which you copy the example directory *qsys-examples*, which contains the directory *ex1_back_to_back_sv* from the Installation.

   a. Using the *mkdir* command, create the work directory into which you will copy the *qsys-examples* directory.

   ```
   mkdir axi3-qsys-examples
   ```

   b. Using the *cp* command, copy the *qsys-examples* directory from the Installation directory into your work directory.

   ```
   cp -r $QUARTUS_ROOTDIR/../ip/altera/mentor_vip_ae/axi3/\
      qsys-examples/* axi3-qsys-examples/
   ```

2. Using the *cd* command, change the directory path to your local path where the example resides.

   ```
   cd axi3-qsys-examples/ex1_back_to_back_sv
   ```

3. Now open the Qsys tool. Refer to the Running the Qsys Tool section for details.

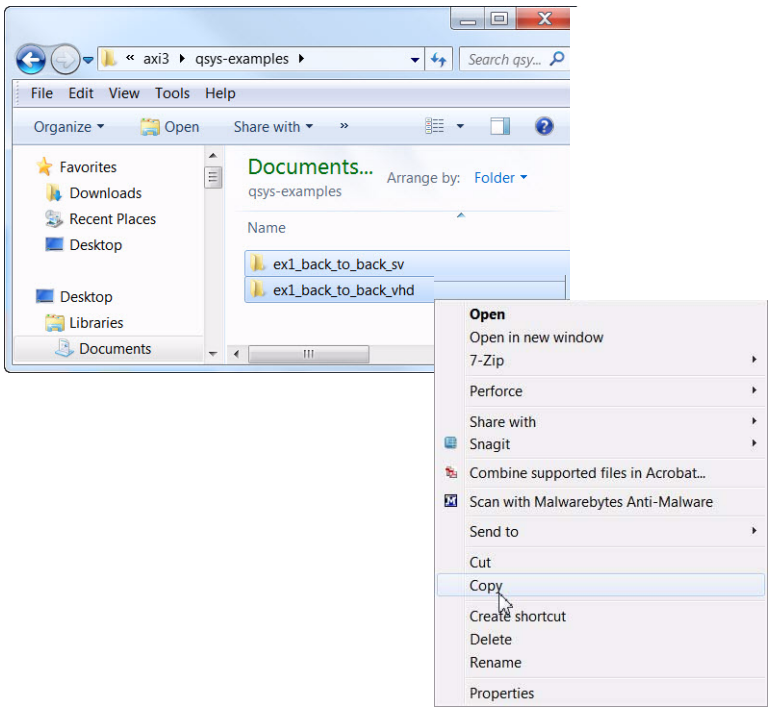
# Setting Up Simulation from the Windows GUI

The following steps outline how to set up the simulation environment from a Windows GUI. This example uses the Windows7 platform.

1. Create a work folder into which you copy the contents of the *qsys-examples* folder, which includes the *ex1_back_to_back_sv* folder from the Installation.

   a. Using the GUI, select a location for your work folder, then click the *New folder* option on the window's menu bar to create and name a work folder. For this example, name the work folder *axi3-qsys-examples*. Refer to figures 12-1 and 12-2 below.

**Figure 12-1. Copy the Contents of *qsys-examples* from the Installation Folder**




   b. Copy the contents of the *qsys-examples* folder from the Installation folder to your work folder.

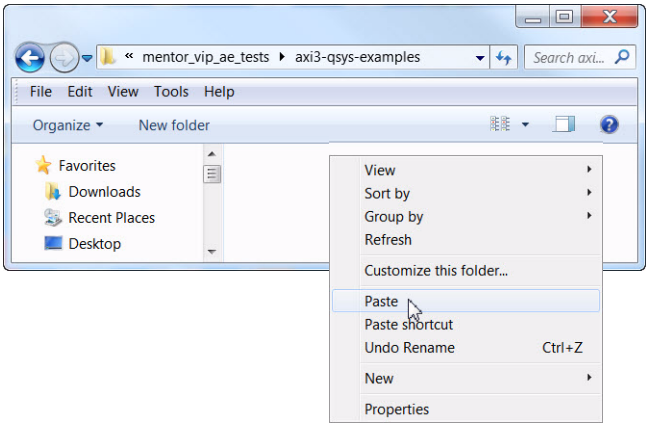
      Open the Installation and work folders. In the Installation folder, double-click the *qsys-examples* folder to select and open it. When the folder opens, type CTRL/A to select the contents of the directory, then right-click to display the drop down menu and select *Copy* from the drop-down menu.

      Go to the open work folder. Double-click on the folder.

When the folder opens, right-click inside the work folder and select *Paste* from the drop-down menu to copy the contents of the *qsys-examples* folder to the new *axi3-qsys-examples* work folder.

Paste the *qsys-examples* from the *Installation* Folder into the *axi3-qsys-examples* work folder.

**Figure 12-2. Paste *qsys-examples* from Installation Folder into Work Folder**




**Note**

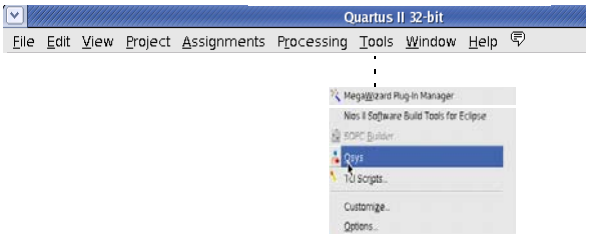
Alternatively, open both folders, the *Installation* folder containing the *qsys-examples* folder and the new *axi3-qsys-examples* work folder. Use the Windows *select*, *drag*, and *drop* functions to select the contents of the *qsys-examples* folder in the *Installation* folder, and then drag the contents to and drop it in the new *axi3-qsys-examples* work folder.

2. After creating the new *axi3-qsys-examples* work folder and copying the contents of the *qsys-examples* to it, open the Qsys tool. Refer to Running the Qsys Tool section for details.

# Running the Qsys Tool

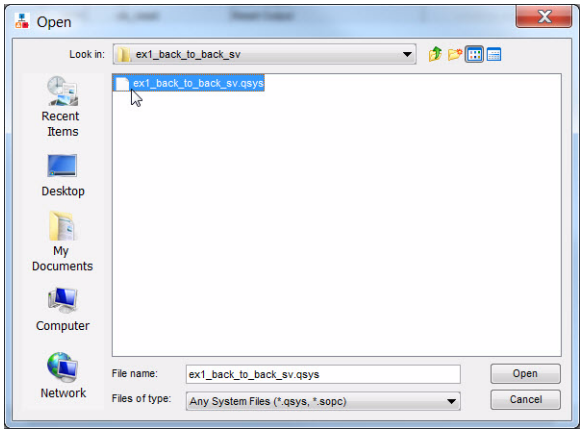
1. Open Qsys in the Quartus II software menu.
   Start the Quartus II software. When the Quartus II GUI appears, select *Tools>Qsys* (refer to Figure 12-3).

**Figure 12-3. Select Qsys from the Quartus II Software Top-Level Menu**




2. From the Qsys open window, use the *File>Open* command to open and select the file *ex1_back_to_back_sv.qsys*. On a Windows platform, this Qsys file is in the directory *axi3-qsys-examples\ex1_back_to_back_sv* (refer to Figure 12-4). On a UNIX platform, this file is in the directory *axi3-qsys-examples/ex1_back_to_back_sv*. Select and open the *ex1_back_to_back_sv.qsys* example.

**Figure 12-4. Open the *ex1_back_to_back_sv.qsys* Example**

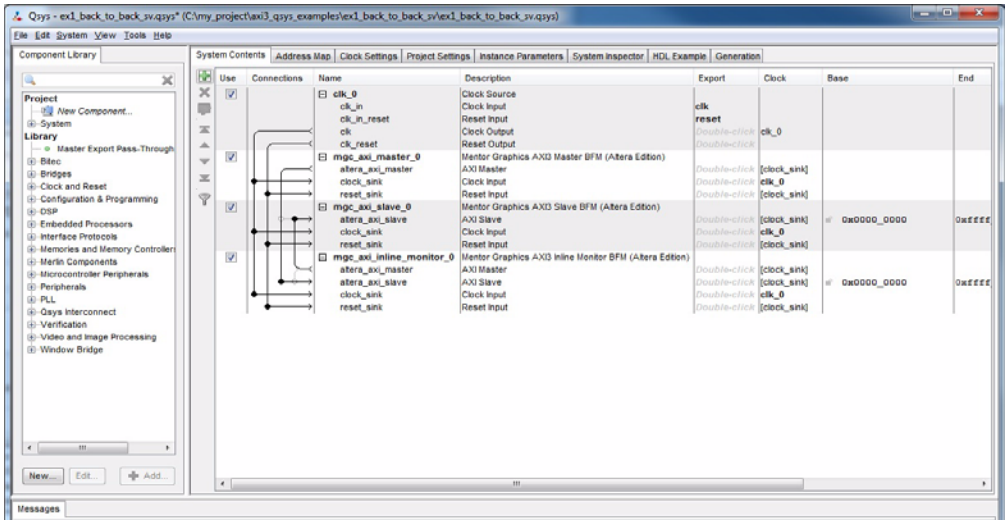



**Note**

If you open the Qsys tool in a subsequent session, a Qsys dialog asks you if you want to open this file.

3. Qsys displays the connectivity of the selected example as shown in Figure 12-5.

**Figure 12-5. Quartus II Software Displays Connectivity of the Example**



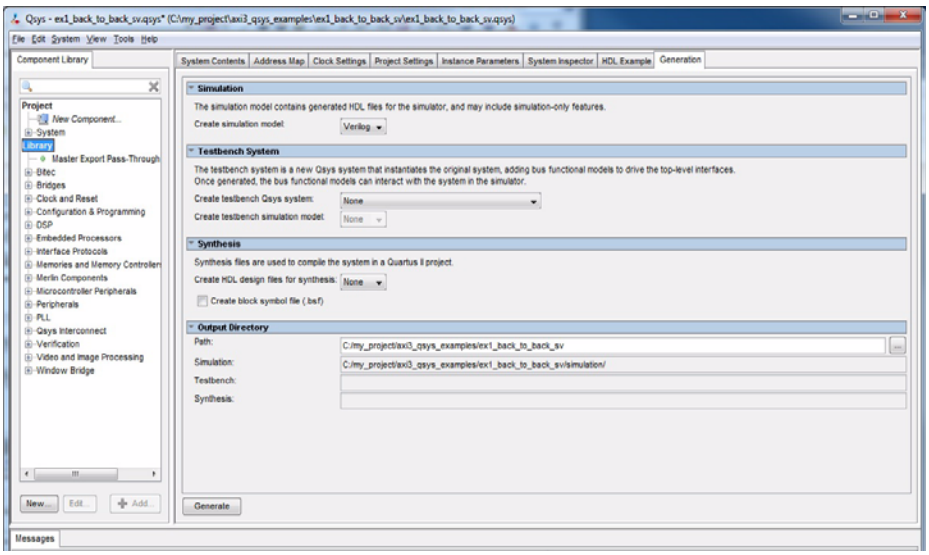
**Note**

If you are using VHDL, you must select each BFM and verify that the index number specified for the BFM is correct. An information dialog displays the properties of the BFM when you select it. Ensure the specified BFM *index* is correct in this dialog. If you do not know the correct index number, check the VHDL code for the BFM.

4. Select the *Generation* tab on the upper right side of the window (refer to Figure 12-5) to display the netlist generation options.

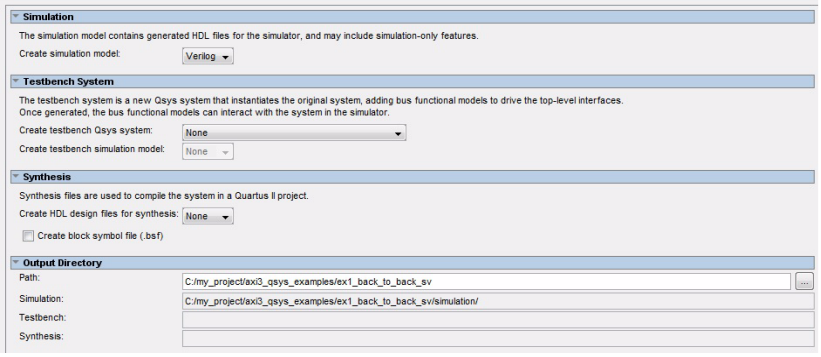
5. Specify the netlist generation options and generate the netlist (Figure 12-6).

**Figure 12-6. Generation Tab Window**



6. Now change the example's path, select the simulation model, and turn off synthesis as outlined in the steps below and shown in Figure 12-7.

**Figure 12-7. Set Path, Simulation, and Synthesis Options**


Simulation
The simulation model contains generated HDL files for the simulator, and may include simulation-only features.
Create simulation model:
Verilog
Testbench System
The testbench system is a new Qsys system that instantiates the original system, adding bus functional models to drive the top-level interfaces.
Once generated, the bus functional models can interact with the system in the simulator.
Create testbench Qsys system:
None
Create testbench simulation model:
None
Synthesis
Synthesis files are used to compile the system in a Quartus II project.
Create HDL design files for synthesis:
None
Create block symbol file (.bsf)
Output Directory
Path:
C:/my_project/axi3_qsys_examples/ex1_back_to_back_sv
Simulation:
C:/my_project/axi3_qsys_examples/ex1_back_to_back_sv/simulation/
Testbench:
Synthesis:

a. Change the example's path. In the Path field of the Output Directory section, ensure the path correctly specifies the subdirectory *ex1_back_to_back_sv*, which is the subdirectory containing the example that you just copied into a temporary directory.

**Note**

If the subdirectory name of the example is duplicated in the example's *Path* field, you must remove one of the duplicated subdirectory names. To reset the path, double-click the square browse button to the right of the *Path* field and locate the path of the example.

The example's path specified by the *Path* field of the Output Directory section **must be correct before** selecting *Verilog* or *VHDL* in the next step.

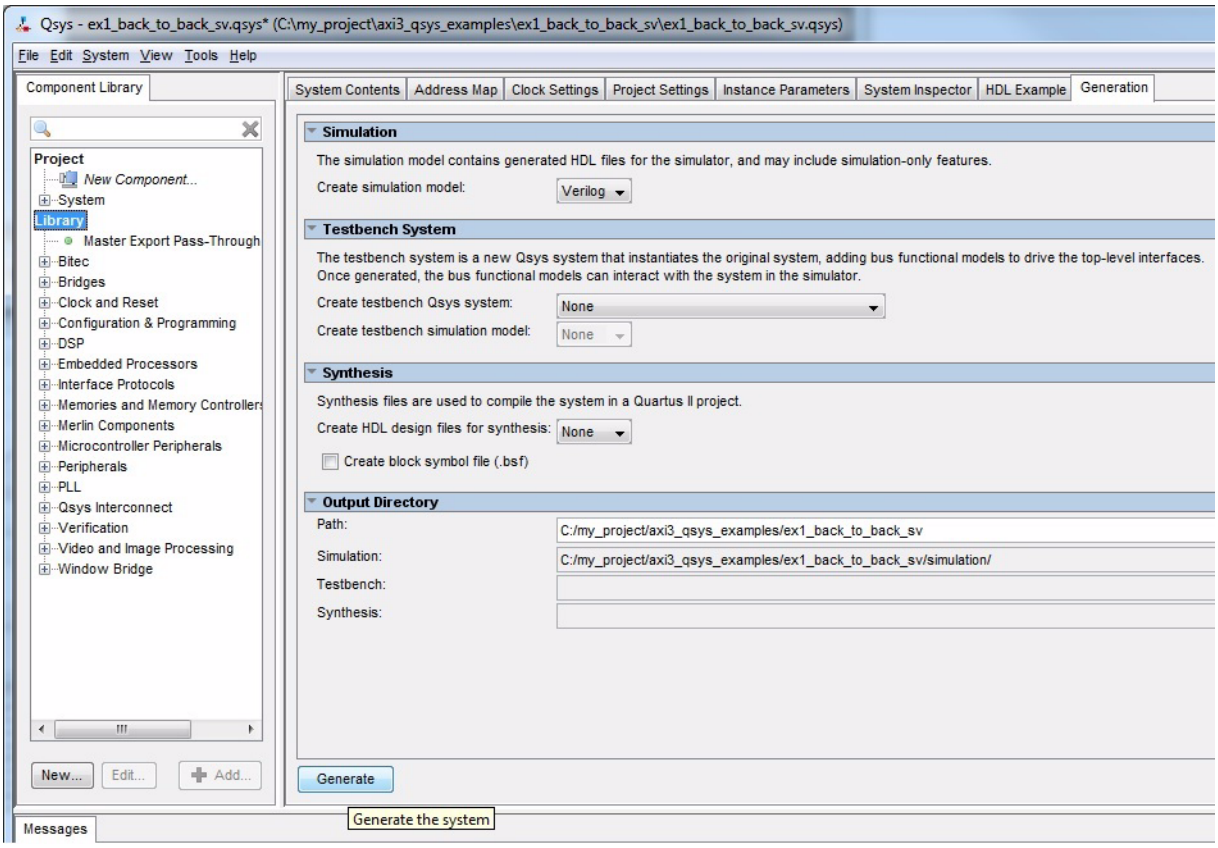
b. Under the Simulation section, select the language for your output files, *Verilog* or *VHDL*, for the value of the *Create simulation model* option (refer to Figure 12-7).

c. Under the Testbench System section the *Create testbench Qsys system* should be set to *None*, along with the *Create testbench simulation model* option (refer to Figure 12-7).

d. Under the Synthesis section the *Create HDL design files for synthesis* should be set to *None*, and the *Create block symbol file* unchecked (refer to Figure 12-7).

e. Click the *Generate* button on the bottom left side of the window (refer to Figure 12-8).

**Figure 12-8. Click Generate**




f. Now, refer to the section Running Simulation to start simulation.

## Running Simulation

You can run simulation either from a GUI interface or a command line. However, before starting simulation, you must define the following:

- Check to ensure the $QUARTUS_ROOTDIR environment variable points to the Quartus II software directory in the Quartus II software installation. The example script (*example.do* or *example.vhld.do*) uses this variable to locate the Mentor VIP AE BFM during simulation.
- When using Mentor VIP AE BFM, ensure when you start simulation that the variable *MvcHome* points to the location of the installed Mentor VIP AE BFM. You can set the location of *MvcHome* using one of the following options:
  - Set the *MvcHome* variable in the *modelsim.ini* file, refer to the section "Using a Shortcut or Editing the modelsim.ini File".
  - Specify the *-mvchome* option on the command line as shown in the command line examples in the section "Invoking Simulation From a UNIX Command Line".

The command and script that you specify to run simulation varies based on the simulator. Table 12-1 outlines the file and script names you specify in your simulator command.

**Table 12-1. Simulator and Script Names**

| | Questa Simulation | ModelSim Simulation | IES Simulation | VCS Simulation |
|---|---|---|---|---|
| **README** | README-Questa.txt | README-ModelSim.txt | README-IUS.txt | README-VCS.txt |
| **Script Name** | example.do | example.do | example-ius.sh | example-vcs.sh |

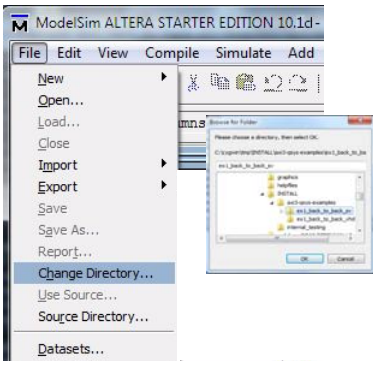
Using the Modelsim simulator, the following sections outline how to run simulation from either a GUI or command line.

## Invoking Simulation From a GUI

Using the ModelSim simulator, this section outlines how to invoke a simulator from a GUI.

1. Start the ModelSim GUI.
2. From the *File* menu, click the *Change Directory* option. When the *Browse for Folder* dialog appears, select the work directory that contains the example.

**Figure 12-9. Select the Work Directory**




3. Start the example script from the Transcript window by typing the following commands:

```
vsim> do example.do
vsim> run -all
```

The first command above starts the script that compiles and elaborates the test programs. The second ModelSim command starts simulation and runs the simulation until simulation completes.

For details about the processing done by the example script, refer to the section "Example Script Processing".

# Invoking Simulation From a UNIX Command Line

This section outlines the commands that you use to run simulation from a command line specified from a UNIX shell.

1. If you are using ModelSim for simulation, set the shared library path with the *mvchome* option.

```
vsim -mvchome $QUARTUS_ROOTDIR/../ip/altera/mentor_vip_ae/common
```

2. Change the directory to the work directory containing the example.

```
cd axi3-qsys-examples/ex1_back_to_back_sv
```

3. At the ModelSim prompt, start the example script.

```
vsim> do example.do
vsim> run -all
```

Alternatively, you can launch the simulator and run the script with one command. However, you must first set the directory to the work directory containing the example as the following commands illustrate.

1. Change the directory to the work directory containing the example.

```
cd axi3-qsys-examples/ex1_back_to_back_sv
```

2. Starting from a UNIX or Windows process, invoke *Modelsim* on the *example.do* script by typing the following command.

```
vsim -mvchome $QUARTUS_ROOTDIR/../ip/altera/\
      mentor_vip_ae/common -gui -do example.do
```

3. When ModelSim starts, type the run -all command.

```
vsim> run -all
```

4. When ModelSim prompts you to finish, click the *yes* option.

**Note**

If your example is a VHDL example, the script name is *example_vhdl.do*

For details on the processing done by the script, refer to Example Script Processing.

# Example Script Processing

After starting one of the example scripts from Table 12-1, the script compiles the Mentor VIP AE BFM for AXI3, then invokes two *tcl* aliases—*dev_com* and *com* to compile the required design files. These alias commands are defined in the *msim_setup.tcl* simulation script generated by Qsys along with the simulation model files.

Next, *vlog* compiles the three test programs:

- *master_test_program.sv*
- *slave_test_program.sv*
- *monitor_test_program.sv*

The script then uses *vlog* again to compile the *top.sv*. Simulation starts with the *elab* alias.

```
set TOP_LEVEL_NAME top
set QSYS_SIMDIR    simulation

source $QSYS_SIMDIR/mentor/msim_setup.tcl
if {![info exists env(MENTOR_VIP_AE)]} {
  set env(MENTOR_VIP_AE)\
   $env(QUARTUS_ROOTDIR)/../ip/altera/mentor_vip_ae
}

ensure_lib libraries
ensure_lib libraries/work
vmap work  libraries/work

vlog -work work -sv \
    $env(MENTOR_VIP_AE)/common/questa_mvc_svapi.svh \
    $env(MENTOR_VIP_AE)/axi3/bfm/mgc_common_axi.sv \
    $env(MENTOR_VIP_AE)/axi3/bfm/mgc_axi_monitor.sv \
    $env(MENTOR_VIP_AE)/axi3/bfm/mgc_axi_inline_monitor.sv \
    $env(MENTOR_VIP_AE)/axi3/bfm/mgc_axi_master.sv \
    $env(MENTOR_VIP_AE)/axi3/bfm/mgc_axi_slave.sv

# Compile device library files
dev_com

# Compile Qsys-generated design files
com

# Compile example test program files
vlog  master_test_program.sv
vlog   slave_test_program.sv
vlog monitor_test_program.sv

# Compile top-level design file
vlog top.sv

# Simulate
elab
```

# Using a Shortcut or Editing the modelsim.ini File

On Windows, if you use a shortcut or if you want to ensure the path specification is correct before simulation, edit the *modelsim.ini* file, which provides the path to the Mentor VIP AE installation for all future invocations of ModelSim or Questa.

To edit the ModelSim/Questa installation directory follow these steps:

1. Edit the file *modelsim.ini*, find the section that starts with *[vsim]*.
2. Search for *MvcHome*. If it is not already defined in the *modelsim.ini* file, you must add it. You can add this variable at any location in the *[vsim]* section.

   If the *modelsim.ini* file is read-only, you must modify it to allow write access.
3. Add or change the *MvcHome* path to point to the location where the Mentor VIP AE is installed. Do not forget the *common* subdirectory. For example:

```
MvcHome = $QUARTUS_ROOTDIR/../ip/altera/mentor_vip_ae/common
```

**Note**

Setting *MvcHome* to the *modelsim.ini* file eliminates the need to specify the *-mvchome* option on the vsim command line.

Do not use *vmap* to specify the installed location of Mentor VIP AE. Using *vmap* puts the *MvcHome* in the [library] section of *modelsim.ini*.

```
vmap MvcHome $QUARTUS_ROOTDIR/../ip/altera/mentor_vip_ae/common
```

**Note**

ModelSim Altera Edition and ModelSim Altera Starter Edition do not have a default path defined for the variable *MvcHome*. If you are using either of these simulators, you must define a path for this variable by adding a new entry to the file. Be sure to add the entry in the *[vsim]* section of the file (after the notation *[vsim]*, and before the next section). Also, if the file is read-only, modify the file access to allow write access.

# Appendix A
# Assertions

## AXI3 Assertions

The AXI3 Master, Slave, and Monitor BFMs all support error checking with the firing of one or more assertions when a property defined in the AMBA AXI Protocol Specification has been violated. Each assertion can be individually enabled/disabled using the *set_config()* function for a particular BFM. The property covered for each assertion is noted in Table A-1 under the Property Reference column. The reference number refers to the section number in the AMBA AXI Protocol Specification.

**Table A-1. AXI3 Assertions**

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI3-60000 | AXI_ADDR_FOR_READ_BURST_ACROSS_4K_BOUNDARY | This read transaction has crossed a 4KB boundary. | A3.4.1 |
| AXI3-60001 | AXI_ADDR_FOR_WRITE_BURST_ACROSS_4K_BOUNDARY | This write transaction has crossed a 4KB boundary. | A3.4.1 |
| AXI3-60002 | AXI_ARADDR_CHANGED_BEFORE_ARREADY | The value of *ARADDR* has changed from its initial value between the time *ARVALID* was asserted, and before *ARREADY* was asserted. | A3.2.1 |
| AXI3-60003 | AXI_ARADDR_UNKN | *ARADDR* has an X or Z value. | A2.5 |
| AXI3-60004 | AXI_ARBURST_CHANGED_BEFORE_ARREADY | The value of *ARBURST* has changed from its initial value between the time *ARVALID* was asserted, and before *ARREADY* was asserted. | A3.2.1 |
| AXI3-60005 | AXI_ARBURST_UNKN | *ARBURST* has an X or Z value. | A2.5 |
| AXI3-60006 | AXI_ARCACHE_CHANGED_BEFORE_ARREADY | The value of *ARCACHE* has changed from its initial value between the time *ARVALID* was asserted, and before *ARREADY* was asserted. | A3.2.1 |
| AXI3-60007 | AXI_ARCACHE_UNKN | *ARCACHE* has an X or Z value. | A2.5 |
| AXI3-60008 | AXI_ARID_CHANGED_BEFORE_ARREADY | The value of *ARID* has changed from its initial value between the time *ARVALID* was asserted, and before *ARREADY* was asserted. | A3.2.1 |

## Table A-1. AXI3 Assertions

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI3-60009 | AXI_ARID_UNKN | *ARID* has an X or Z value. | A2.5 |
| AXI3-60010 | AXI_ARLEN_CHANGED_BEFORE_ARREADY | The value of *ARLEN* has changed from its initial value between the time *ARVALID* was asserted, and before *ARREADY* was asserted. | A3.2.1 |
| AXI3-60011 | AXI_ARLEN_UNKN | *ARLEN* has an X or Z value. | A2.5 |
| AXI3-60012 | AXI_ARLOCK_CHANGED_BEFORE_ARREADY | The value of *ARLOCK* has changed from its initial value between the time *ARVALID* was asserted, and before *ARREADY* was asserted. | A3.2.1 |
| AXI3-60013 | AXI_ARLOCK_UNKN | *ARLOCK* has an X or Z value. | A2.5 |
| AXI3-60014 | AXI_ARPROT_CHANGED_BEFORE_ARREADY | The value of *ARPROT* has changed from its initial value between the time *ARVALID* was asserted, and before *ARREADY* was asserted. | A3.2.1 |
| AXI3-60015 | AXI_ARPROT_UNKN | *ARPROT* has an X or Z value. | A2.5 |
| AXI3-60016 | AXI_ARREADY_UNKN | *ARREADY* has an X or Z value. | A2.5 |
| AXI3-60017 | AXI_ARSIZE_CHANGED_BEFORE_ARREADY | The value of *ARSIZE* has changed from its initial value between the time *ARVALID* was asserted, and before *ARREADY* was asserted. | A3.2.1 |
| AXI3-60018 | AXI_ARSIZE_UNKN | *ARSIZE* has an X or Z value. | A2.5 |
| AXI3-60019 | AXI_ARUSER_CHANGED_BEFORE_ARREADY | The value of *ARUSER* has changed from its initial value between the time *ARVALID* was asserted, and before *ARREADY* was asserted. | A3.2.1 |
| AXI3-60020 | AXI_ARUSER_UNKN | *ARUSER* has an X or Z value. | A2.5 |
| AXI3-60021 | AXI_ARVALID_DEASSERTED_BEFORE_ARREADY | *ARVALID* has been de-asserted before *ARREADY* was asserted. | A3.2.1 |
| AXI3-60022 | AXI_ARVALID_HIGH_ON_FIRST_CLOCK_AFTER_RESET | A master interface must begin driving *ARVALID* high only at a rising clock edge after *ARESETn* is *HIGH.* | A3.1.2 |
| AXI3-60023 | AXI_ARVALID_UNKN | *ARVALID* has an X or Z value. | A2.5 |

## Table A-1. AXI3 Assertions

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI3-60024 | AXI_AWADDR_CHANGED_BEFORE_AWREADY | The value of *AWADDR* has changed from its initial value between the time *AWVALID* was asserted, and before *AWREADY* was asserted. | A3.2.1 |
| AXI3-60025 | AXI_AWADDR_UNKN | *AWADDR* has an X or Z value. | A2.2 |
| AXI3-60026 | AXI_AWBURST_CHANGED_BEFORE_AWREADY | The value of *AWBURST* has changed from its initial value between the time *AWVALID* was asserted, and before *AWREADY* was asserted. | A3.2.1 |
| AXI3-60027 | AXI_AWBURST_UNKN | *AWBURST* has an X or Z value. | A2.2 |
| AXI3-60028 | AXI_AWCACHE_CHANGED_BEFORE_AWREADY | The value of *AWCACHE* has changed from its initial value between the time *AWVALID* was asserted, and before *AWREADY* was asserted. | A3.2.1 |
| AXI3-60029 | AXI_AWCACHE_UNKN | *AWCACHE* has an X or Z value. | A2.2 |
| AXI3-60030 | AXI_AWID_CHANGED_BEFORE_AWREADY | The value of *AWID* has changed from its initial value between the time *AWVALID* was asserted, and before *AWREADY* was asserted (SPEC3(3.1)) | A3.2.1 |
| AXI3-60031 | AXI_AWID_UNKN | *AWID* has an X or Z value. | A2.2 |
| AXI3-60032 | AXI_AWLEN_CHANGED_BEFORE_AWREADY | The value of *AWLEN* has changed from its initial value between the time *AWVALID* was asserted, and before *AWREADY* was asserted. | A3.2.1 |
| AXI3-60033 | AXI_AWLEN_UNKN | *AWLEN* has an X or Z value. | A2.2 |
| AXI3-60034 | AXI_AWLOCK_CHANGED_BEFORE_AWREADY | The value of *AWLOCK* has changed from its initial value between the time *AWVALID* was asserted, and before *AWREADY* was asserted. | A3.2.1 |
| AXI3-60035 | AXI_AWLOCK_UNKN | *AWLOCK* has an X or Z value. | A2.2 |

## Table A-1. AXI3 Assertions

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI3-60036 | AXI_AWPROT_CHANGED_BEFORE_AWREADY | The value of *AWPROT* has changed from its initial value between the time *AWVALID* was asserted, and before *AWREADY* was asserted. | A3.2.1 |
| AXI3-60037 | AXI_AWPROT_UNKN | *AWPROT* has an X or Z value. | A2.2 |
| AXI3-60038 | AXI_AWREADY_UNKN | *AWREADY* has an X or Z value. | A2.2 |
| AXI3-60039 | AXI_AWSIZE_CHANGED_BEFORE_AWREADY | The value of *AWSIZE* has changed from its initial value between the time *AWVALID* was asserted, and before *AWREADY* was asserted. | A3.2.1 |
| AXI3-60040 | AXI_AWSIZE_UNKN | *AWSIZE* has an X or Z value. | A2.2 |
| AXI3-60041 | AXI_AWUSER_CHANGED_BEFORE_AWREADY | The value of *AWUSER* has changed from its initial value between the time *AWVALID* was asserted, and before *AWREADY* was asserted. | A3.2.1 |
| AXI3-60042 | AXI_AWUSER_UNKN | *AWUSER* has an X or Z value. | A2.2 |
| AXI3-60043 | AXI_AWVALID_DEASSERTED_BEFORE_AWREADY | *AWVALID* has been de-asserted before *AWREADY* was asserted. | A3.2.1 |
| AXI3-60044 | AXI_AWVALID_HIGH_ON_FIRST_CLOCK_AFTER_RESET | A master interface must begin driving *AWVALID* high only at a rising clock edge after *ARESETn* is *HIGH*. | A3.1.2 |
| AXI3-60045 | AXI_AWVALID_UNKN | *AWVALID* has an X or Z value. | A2.2 |
| AXI3-60046 | AXI_BID_CHANGED_BEFORE_BREADY | The value of *BID* has changed from its initial value between the time *BVALID* was asserted, and before *BREADY* was asserted. | A3.2.1 |
| AXI3-60047 | AXI_BID_UNKN | *BID* has an X or Z value. | A2.4 |
| AXI3-60048 | AXI_BREADY_NOT_ASSERTED_AFTER_BVALID | Once *BVALID* has been asserted, *BREADY* should be asserted within *config_max_latency_BVALID_assertion_to_BREADY* clock periods. | - |
| AXI3-60049 | AXI_BREADY_UNKN | *BREADY* has an X or Z value. | A2.4 |
| AXI3-60050 | AXI_BRESP_CHANGED_BEFORE_BREADY | The value of *BRESP* has changed from its initial value between the time *BVALID* was asserted, and before *BREADY* was asserted (SPEC3(3.1)). | A3.2.1 |

## Table A-1. AXI3 Assertions

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI3-60051 | AXI_BRESP_UNKN | *BRESP* has an X or Z value. | A2.4 |
| AXI3-60054 | AXI_BVALID_DEASSERTED_BEFORE_BREADY | *BVALID* has been de-asserted before *BREADY* was asserted. | A3.2.1 |
| AXI3-60055 | AXI_BVALID_HIGH_ON_FIRST_CLOCK_AFTER_RESET | A slave interface must begin driving *BVALID* high only at a rising clock edge after *ARESETn* is *HIGH*. | A3.1.2 |
| AXI3-60056 | AXI_BVALID_UNKN | *BVALID* has an X or Z value. | A2.4 |
| AXI3-60057 | AXI_EXCLUSIVE_READ_ACCESS_MODIFIABLE | The modifiable bit (bit 1 of the cache transaction field) should not be set for an exclusive read access. | A7.2.4 |
| AXI3-60058 | AXI_EXCLUSIVE_READ_BYTES_TRANSFER_EXCEEDS_128 | Number of bytes in an exclusive read transaction must be less than or equal to 128. | A7.2.4 |
| AXI3-60059 | AXI_EXCLUSIVE_WRITE_BYTES_TRANSFER_EXCEEDS_128 | Number of bytes in an exclusive write transaction must be less than or equal to 128. | A7.2.4 |
| AXI3-60060 | AXI_EXCLUSIVE_READ_BYTES_TRANSFER_NOT_POWER_OF_2 | Number of bytes of an exclusive read transaction is not a power of 2. | A7.2.4 |
| AXI3-60061 | AXI_EXCLUSIVE_WRITE_BYTES_TRANSFER_NOT_POWER_OF_2 | Number of bytes of an exclusive write transaction is not a power of 2. | A7.2.4 |
| AXI3-60062 | AXI_EXCLUSIVE_WR_ADDRESS_NOT_SAME_AS_RD | Exclusive write does not match the address of the previous exclusive read to this id. | A7.2.4 |
| AXI3-60063 | AXI_EXCLUSIVE_WR_BURST_NOT_SAME_AS_RD | Exclusive write does not match the burst setting of the previous exclusive read to this id. | A7.2.4 |
| AXI3-60064 | AXI_EXCLUSIVE_WR_CACHE_NOT_SAME_AS_RD | Exclusive write does not match the cache setting of the previous exclusive read to this id. | A7.2.4 |
| AXI3-60065 | AXI_EXCLUSIVE_WRITE_ACCESS_MODIFIABLE | The modifiable bit (bit 1 of the cache transaction field) should not be set for an exclusive write access. | A7.2.4 |
| AXI3-60066 | AXI_EXCLUSIVE_WR_LENGTH_NOT_SAME_AS_RD | Exclusive write does not match the length of the previous exclusive read to this id. | A7.2.4 |

## Table A-1. AXI3 Assertions

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI3-60067 | AXI_EXCLUSIVE_WR_PROT_NOT_SAME_AS_RD | Exclusive write does not match the prot setting of the previous exclusive read to this id. | A7.2.4 |
| AXI3-60068 | AXI_EXCLUSIVE_WR_SIZE_NOT_SAME_AS_RD | Exclusive write does not match the size of the previous exclusive read to this id. | A7.2.4 |
| AXI3-60069 | AXI_EXOKAY_RESPONSE_NORMAL_READ | Slave has responded *AXI_EXOKAY* to a nonexclusive read transfer. | - |
| AXI3-60070 | AXI_EXOKAY_RESPONSE_NORMAL_WRITE | Slave has responded *AXI_EXOKAY* to a nonexclusive write transfer. | - |
| AXI3-60071 | AXI_EX_RD_RESP_MISMATCHED_WITH_EXPECTED_RESP | Expected response to this exclusive read did not matched with the actual response. | A7.2.3 |
| AXI3-60072 | AXI_EX_WR_RESP_MISMATCHED_WITH_EXPECTED_RESP | Expected response to this exclusive write did not matched with the actual response. | A7.2.3 |
| AXI3-60073 | AXI_EX_RD_EXOKAY_RESP_SLAVE_WITHOUT_EXCLUSIVE_ACCESS | Response for an exclusive read to a slave which does not support exclusive access should be *AXI_OKAY,* but it returned *AXI_EXOKAY.* | A7.2.3 |
| AXI3-60074 | AXI_EX_WRITE_BEFORE_EX_READ_RESPONSE | Exclusive write has occurred, with no previous exclusive read. | A7.2.2 |
| AXI3-60075 | AXI_EX_WRITE_EXOKAY_RESP_SLAVE_WITHOUT_EXCLUSIVE_ACCESS | Response for an exclusive write to a slave which does not support exclusive access should be *AXI_OKAY*, but it returned *AXI_EXOKAY.* | A7.2.3 |
| AXI3-60076 | AXI_ILLEGAL_LENGTH_WRAPPING_READ_BURST | In the last read address phase burst_length has an illegal value for a burst of type *AXI_WRAP*. | A3.4.1 |
| AXI3-60077 | AXI_ILLEGAL_LENGTH_WRAPPING_WRITE_BURST | In the last write address phase *burst_length* has an illegal value for a burst of type *AXI_WRAP*. | A3.4.1 |
| AXI3-60078 | AXI_ILLEGAL_RESPONSE_EXCLUSIVE_READ | Response for an exclusive read should be either *AXI_OKAY or AXI_EXOKAY*. | A7.2.3 |
| AXI3-60079 | AXI_ILLEGAL_RESPONSE_EXCLUSIVE_WRITE | Response for an exclusive write should be either *AXI_OKAY or AXI_EXOKA*Y. | A7.2.3 |
| AXI3-60080 | AXI_PARAM_READ_DATA_BUS_WIDTH | The value of *AXI_RDATA_WIDTH* must be one of 8,16,32,64,128,256,512,1024. | A1.3.1 |
| AXI3-60081 | AXI_PARAM_WRITE_DATA_BUS_WIDTH | The value of *AXI_WDATA_WIDTH* must be one of 8,16,32,64,128,256,512,1024. | A1.3.1 |
| AXI3-60082 | AXI_READ_ALLOCATE_WHEN_NON_MODIFIABLE_12 | The *RA* bit of the cache transaction field should not be *HIGH* when the Modifiable bit is *LOW*. | A4.4 |

## Table A-1. AXI3 Assertions

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI3-60083 | AXI_READ_ALLOCATE_WHEN_NON_MODIFIABLE_13 | The *RA* bit of the cache transaction field should not be *HIGH* when the Modifiable bit is *LOW*. | A4.4 |
| AXI3-60084 | AXI_READ_ALLOCATE_WHEN_NON_MODIFIABLE_4 | The *RA* of the cache transaction field bit should not be *HIGH* when the Modifiable bit is *LOW*. | A4.4 |
| AXI3-60085 | AXI_READ_ALLOCATE_WHEN_NON_MODIFIABLE_5 | The *RA* of the cache transaction field bit should not be *HIGH* when the Modifiable bit is *LOW*. | A4.4 |
| AXI3-60086 | AXI_READ_ALLOCATE_WHEN_NON_MODIFIABLE_8 | The *RA* of the cache transaction field bit should not be *HIGH* when the Modifiable bit is *LOW*. | A4.4 |
| AXI3-60087 | AXI_READ_ALLOCATE_WHEN_NON_MODIFIABLE_9 | The *RA* of the cache transaction field bit should not be *HIGH* when the Modifiable bit is *LOW*. | A4.4 |
| AXI3-60088 | AXI_READ_BURST_LENGTH_VIOLATION | The number of beats actually read does not match the burst length defined by the *ARLEN*. | A3.4.1 |
| AXI3-60089 | AXI_READ_BURST_SIZE_VIOLATION | In this read transaction, size has been set greater than the defined data bus. | A3.4.1 |
| AXI3-60090 | AXI_READ_DATA_BEFORE_ADDRESS | An unexpected read response has occurred (there are no outstanding read transactions with this id). | A3.3.1 |
| AXI3-60091 | AXI_READ_DATA_CHANGED_BEFORE_RREADY | The value of *RDATA* has changed from its initial value between the time *RVALID* was asserted, and before *RREADY* was asserted. | A3.2.1 |
| AXI3-60092 | AXI_READ_DATA_UNKN | *RDATA* has an X or Z value. | A2.6 |
| AXI3-60093 | AXI_RESERVED_ARLOCK_ENCODING | The reserved encoding of 2'b11 should not be used for *ARLOCK*. | A7.4 |
| AXI3-60094 | AXI_READ_RESP_CHANGED_BEFORE_RREADY | The value of *RRESP* has changed from its initial value between the time *RVALID* was asserted, and before *RREADY* was asserted. | A3.2.1 |
| AXI3-60095 | AXI_RESERVED_ARBURST_ENCODING | The reserved encoding of 2'b11 should not be used for *ARBURST*. | A3.4.1 |
| AXI3-60096 | AXI_RESERVED_AWBURST_ENCODING | The reserved encoding of 2'b11 should not be used for *AWBURST*. | A3.4.1 |
| AXI3-60097 | AXI_RID_CHANGED_BEFORE_RREADY | The value of *RID* has changed from its initial value between the time *RVALID* was asserted, and before *RREADY* was asserted. | A3.2.1 |

**Table A-1. AXI3 Assertions**

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI3-60098 | AXI_RID_UNKN | *RID* has an X or Z value. | A2.6 |
| AXI3-60099 | AXI_RLAST_CHANGED_BEFORE_RREADY | The value of *RLAST* has changed from its initial value between the time *RVALID* was asserted, and before *RREADY* was asserted. | A3.2.1 |
| AXI3-60100 | AXI_RLAST_UNKN | *RLAST* has an X or Z value. | A2.6 |
| AXI3-60101 | AXI_RREADY_UNKN | *RREADY* has an X or Z value. | A2.6 |
| AXI3-60102 | AXI_RRESP_UNKN | *RRESP* has an X or Z value. | A2.6 |
| AXI3-60105 | AXI_RVALID_DEASSERTED_BEFORE_RREADY | *RVALID* has been de-asserted before *RREADY* was asserted. | A3.2.1 |
| AXI3-60106 | AXI_RVALID_HIGH_ON_FIRST_CLOCK_AFTER_RESET | A slave interface must begin driving *RVALID* high only at a rising clock edge after *ARESETn* is *HIGH*. | A3.1.2 |
| AXI3-60107 | AXI_RVALID_UNKN | *RVALID* has an X or Z value. | A2.6 |
| AXI3-60108 | AXI_UNALIGNED_ADDRESS_FOR_EXCLUSIVE_READ | Exclusive read accesses must have address aligned to the total number of bytes in the transaction. | A7.2.4 |
| AXI3-60109 | AXI_UNALIGNED_ADDRESS_FOR_EXCLUSIVE_WRITE | Exclusive write accesses must have address aligned to the total number of bytes in the transaction. | A7.2.4 |
| AXI3-60110 | AXI_UNALIGNED_ADDR_FOR_WRAPPING_READ_BURST | Wrapping bursts must have address aligned to the start of the read transfer. | A3.4.1 |
| AXI3-60111 | AXI_UNALIGNED_ADDR_FOR_WRAPPING_WRITE_BURST | Wrapping bursts must have address aligned to the start of the write transfer. | A3.4.1 |
| AXI3-60112 | AXI_WDATA_CHANGED_BEFORE_WREADY_ON_INVALID_LANE | On a lane whose strobe is 0, the value of *WDATA* has changed from its initial value between the time *WVALID* was asserted, and before *WREADY* was asserted. | A3.2.1 |
| AXI3-60113 | AXI_WDATA_CHANGED_BEFORE_WREADY_ON_VALID_LANE | On a lane whose strobe is 1, the value of *WDATA* has changed from its initial value between the time *WVALID* was asserted, and before *WREADY* was asserted. | A3.2.1 |

## Table A-1. AXI3 Assertions

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI3-60114 | AXI_WLAST_CHANGED_BEFORE_WREADY | The value of *WLAST* has changed from its initial value between the time *WVALID* was asserted, and before *WREADY* was asserted. | A3.2.1 |
| AXI3-60115 | AXI_WID_CHANGED_BEFORE_WREADY | The value of *WID* has changed from its initial value between the time *WVALID* was asserted, and before *WREADY* was asserted. | A3.2.1 |
| AXI3-60116 | AXI_WLAST_UNKN | *WLAST* has an X or Z value. | A2.3 |
| AXI3-60117 | AXI_WREADY_UNKN | *WREADY* has an X or Z value. | A2.3 |
| AXI3-60118 | AXI_WRITE_ALLOCATE_WHEN_NON_MODIFIABLE_12 | The *WA* bit of the cache transaction field should not be *HIGH* when the Modifiable bit is *LOW*. | A4.4 |
| AXI3-60119 | AXI_WRITE_ALLOCATE_WHEN_NON_MODIFIABLE_13 | The *WA* of the cache transaction field bit should not be *HIGH* when the Modifiable bit is *LOW*. | A4.4 |
| AXI3-60120 | AXI_WRITE_ALLOCATE_WHEN_NON_MODIFIABLE_4 | The *WA* of the cache transaction field bit should not be *HIGH* when the Modifiable bit is *LOW*. | A4.4 |
| AXI3-60121 | AXI_WRITE_ALLOCATE_WHEN_NON_MODIFIABLE_5 | The *WA* of the cache transaction field bit should not be *HIGH* when the Modifiable bit is *LOW*. | A4.4 |
| AXI3-60122 | AXI_WRITE_ALLOCATE_WHEN_NON_MODIFIABLE_8 | The *WA* of the cache transaction field bit should not be *HIGH* when the Modifiable bit is *LOW*. | A4.4 |
| AXI3-60123 | AXI_WRITE_ALLOCATE_WHEN_NON_MODIFIABLE_9 | The *WA* of the cache transaction field bit should not be *HIGH* when the Modifiable bit is *LOW*. | A4.4 |
| AXI3-60124 | AXI_WRITE_BURST_SIZE_VIOLATION | In this write transaction, size has been set greater than the defined data bus width. | A3.4.1 |
| AXI3-60125 | AXI_WRITE_DATA_BEFORE_ADDRESS | A write data beat has occurred before the corresponding address phase. | - |
| AXI3-60126 | AXI_WRITE_DATA_UNKN_ON_INVALID_LANE | On a lane whose strobe is 0, *WDATA* has an X or Z value. | A2.3 |
| AXI3-60127 | AXI_WRITE_DATA_UNKN_ON_VALID_LANE | On a lane whose strobe is 1, *WDATA* has an X or Z value. | A2.3 |
| AXI3-60128 | AXI_RESERVED_AWLOCK_ENCODING | The reserved encoding of 2'b11 should not be used for *AWLOCK*. | A7.4 |

## Table A-1. AXI3 Assertions

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI3-60129 | AXI_WRITE_STROBE_ON_INVALID_BYTE_LANES | Write strobe(s) incorrect for the address/size of a fixed transfer. | A2.3 |
| AXI3-60130 | AXI_WSTRB_CHANGED_BEFORE_WREADY | The value of *WSTRB* has changed from its initial value between the time *WVALID* was asserted, and before *WREADY* was asserted. | A3.2.1 |
| AXI3-60131 | AXI_WSTRB_UNKN | *WSTRB* has an X or Z value. | A2.3 |
| AXI3-60134 | AXI_WVALID_DEASSERTED_BEFORE_WREADY | *WVALID* has been de-asserted before *WREADY* was asserted. | A3.2.1 |
| AXI3-60135 | AXI_WVALID_HIGH_ON_FIRST_CLOCK_AFTER_RESET | A master interface must begin driving *WVALID* high only at a rising clock edge after *ARESETn* is *HIGH*. | A3.1.2 |
| AXI3-60136 | AXI_WVALID_UNKN | *WVALID* has an X or Z value. | A2.3 |
| AXI3-60137 | AXI_ADDR_ACROSS_4K_WITHIN_LOCKED_WRITE_TRANSACTION | Transactions in a locked write sequence should be in the same 4K address boundary. | A7.3 |
| AXI3-60138 | AXI_ADDR_ACROSS_4K_WITHIN_LOCKED_READ_TRANSACTION | Transactions in a locked read sequence should be in the same 4K address boundary. | A7.3 |
| AXI3-60139 | AXI_AWID_CHANGED_WITHIN_LOCKED_TRANSACTION | Master should not change the awid in the locked transaction. | A7.3 |
| AXI3-60140 | AXI_ARID_CHANGED_WITHIN_LOCKED_TRANSACTION | Master should not change the arid in the locked transaction. | A7.3 |
| AXI3-60141 | AXI_AWPROT_CHANGED_WITHIN_LOCKED_TRANSACTION | Master should not change the awprot in the locked transaction. | A7.3 |
| AXI3-60142 | AXI_ARPROT_CHANGED_WITHIN_LOCKED_TRANSACTION | Master should not change the arprot in the locked transaction. | A7.3 |
| AXI3-60143 | AXI_AWCACHE_CHANGED_WITHIN_LOCKED_TRANSACTION | Master should not change the awcache in the locked transaction. | A7.3 |
| AXI3-60144 | AXI_ARCACHE_CHANGED_WITHIN_LOCKED_TRANSACTION | Master should not change the arcache in the locked transaction. | A7.3 |
| AXI3-60145 | AXI_NUMBER_OF_LOCKED_SEQUENCES_EXCEEDS_2 | Number of accesses in a locked sequence should not be more than 2. | A7.3 |
| AXI3-60146 | AXI_LOCKED_WRITE_BEFORE_COMPLETION_OF_PREVIOUS_WRITE_TRANSACTIONS | A locked write sequence should not commence before completion of all previously issued write addresses. | A7.3 |

**Table A-1. AXI3 Assertions**

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI3-60147 | AXI_LOCKED_WRITE_BEFORE_COMPLETION_OF_PREVIOUS_READ_TRANSACTIONS | A locked write sequence should not commence before completion of all previously issued read addresses. | A7.3 |
| AXI3-60148 | AXI_LOCKED_READ_BEFORE_COMPLETION_OF_PREVIOUS_WRITE_TRANSACTIONS | A locked read sequence should not commence before completion of all previously issued write addresses. | A7.3 |
| AXI3-60149 | AXI_LOCKED_READ_BEFORE_COMPLETION_OF_PREVIOUS_READ_TRANSACTIONS | A locked read sequence should not commence before completion of all previously issued read addresses. | A7.3 |
| AXI3-60150 | AXI_NEW_BURST_BEFORE_COMPLETION_OF_UNLOCK_TRANSACTION | The unlocking transaction should be completed before further any transactions are initiated. | A7.3 |
| AXI3-60151 | AXI_UNLOCKED_WRITE_WHILE_OUTSTANDING_LOCKED_WRITES | Unlocking write transaction started while outstanding locked write transaction has not completed. | A7.3 |
| AXI3-60152 | AXI_UNLOCKED_WRITE_WHILE_OUTSTANDING_LOCKED_READS | Unlocking write transaction started while outstanding locked read transaction has not completed. | A7.3 |
| AXI3-60153 | AXI_UNLOCKED_READ_WHILE_OUTSTANDING_LOCKED_WRITES | Unlocking read transaction started while outstanding locked write transaction has not completed. | A7.3 |
| AXI3-60154 | AXI_UNLOCKED_READ_WHILE_OUTSTANDING_LOCKED_READS | Unlocking read transaction started while outstanding locked read transaction has not completed. | A7.3 |
| AXI3-60155 | AXI_UNLOCKING_TRANSACTION_WITH_AN_EXCLUSIVE_ACCESS | Unlocking transaction cannot be an exclusive access transaction. | A7.3 |
| AXI3-60156 | AXI_FIRST_DATA_ITEM_OF_TRANSACTION_WRITE_ORDER_VIOLATION | The order in which a slave receives the first data item of each transaction must be the same as the order in which it receives the addresses for the transaction. | A5.3.3 |
| AXI3-60157 | AXI_AWLEN_MISMATCHED_ACTUAL_LENGTH_OF_WRITE_DATA_BURST_EXCEEDS_AWLEN | Actual length of data burst has exceeded the burst length specified by *AWLEN*. | A3.4.1 |
| AXI3-60158 | AXI_AWLEN_MISMATCHED_WITH_COMPLETED_WRITE_DATA_BURST | *AWLEN* value of write address control does not match with corresponding outstanding write data burst length. | A3.4.1 |

## Table A-1. AXI3 Assertions

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI3-60159 | AXI_WRITE_LENGTH_MISMATCHED_ACTUAL_LENGTH_OF_WRITE_DATA_BURST_EXCEEDS_AWLEN | The actual length of write data burst exceeds with the length specified by *AWLEN*. | A3.4.1 |
| AXI3-60160 | AXI_WLAST_ASSERTED_DURING_DATA_PHASE_OTHER_THAN_LAST | Wlast must only be asserted during the last data phase. | A3.4.1 |
| AXI3-60161 | AXI_WRITE_INTERLEAVE_DEPTH_VIOLATION | Write data bursts should not be interleaved beyond the write interleaving depth. | A5.3.3 |
| AXI3-60162 | AXI_WRITE_RESPONSE_WITHOUT_ADDR | Write response should not be sent before the corresponding address has completed. | A3.3.1 |
| AXI3-60163 | AXI_WRITE_RESPONSE_WITHOUT_DATA | Write response should not be sent before the corresponding write data burst has completed. | A3.3.1 |
| AXI3-60164 | AXI_AWVALID_HIGH_DURING_RESET | *AWVALID* asserted during the reset state. | A3.1.2 |
| AXI3-60165 | AXI_WVALID_HIGH_DURING_RESET | *WVALID* asserted during the reset state | A3.1.2 |
| AXI3-60166 | AXI_BVALID_HIGH_DURING_RESET | BVALID asserted during the reset state | A3.1.2 |
| AXI3-60167 | AXI_ARVALID_HIGH_DURING_RESET | *ARVALID* asserted during the reset state | A3.1.2 |
| AXI3-60168 | AXI_RVALID_HIGH_DURING_RESET | *RVALID* asserted during the reset state | A3.1.2 |
| AXI3-60169 | AXI_RLAST_VIOLATION | *RLAST* signal should be asserted along with the final transfer of the read data burst. | A3.4.1 |
| AXI3-60170 | AXI_EX_WRITE_AFTER_EX_READ_FAILURE | It is recommended that an exclusive write access should not be performed after the corresponding exclusive read failure. | A7.2.2 |
| AXI3-60171 | AXI_TIMEOUT_WAITING_FOR_WRITE_DATA | Timed-out waiting for a data phase in write data burst. | A2.3 |
| AXI3-60172 | AXI_TIMEOUT_WAITING_FOR_WRITE_RESPONSE | Timed-out waiting for a write response. | A2.4 |
| AXI3-60173 | AXI_TIMEOUT_WAITING_FOR_READ_RESPONSE | Timed-out waiting for a read response. | A2.6 |
| AXI3-60174 | AXI_TIMEOUT_WAITING_FOR_WRITE_ADDR_AFTER_DATA | Timed-out waiting for a write address phase to be coming after data. | A2.2 |

**Table A-1. AXI3 Assertions**

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI3-60175 | AXI_DEC_ERR_RESP_FOR_READ | No slave at the address for this read transfer (signalled by <AXI_DECERR>) | |
| AXI3-60176 | AXI_DEC_ERR_RESP_FOR_WRITE | No slave at the address for this write transfer (signalled by <AXI_DECERR>) | |
| AXI3-60177 | AXI_SLV_ERR_RESP_FOR_READ | Slave has detected an error for this read transfer (signalled by <AXI_SLVERR>) | |
| AXI3-60178 | AXI_SLV_ERR_RESP_FOR_WRITE | Slave has detected an error for this write transfer (signalled by <AXI_SLVERR>) | |

# AXI4 Assertions

The AXI4 Master, Slave, and Monitor BFMs all support error checking with the firing of one or more assertions when a property defined in the AMBA AXI Protocol Specification has been violated. Each assertion can be individually enabled/disabled using the *set_config()* function for a particular BFM. The property covered for each assertion is noted in Table A-2 under the Property Reference column. The reference number refers to the section number in the AMBA AXI Protocol Specification.

**Table A-2. AXI4 Assertions**

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI4-60000 | AXI4_ADDRESS_WIDTH_EXCEEDS_64 | AXI4 supports up to 64-bit addressing. | A10.3.1 |
| AXI4-60001 | AXI4_ADDR_FOR_READ_BURST_ACROSS_4K_BOUNDARY | This read transaction has crossed a 4KB boundary. | A3.4.1 |
| AXI4-60002 | AXI4_ADDR_FOR_WRITE_BURST_ACROSS_4K_BOUNDARY | This write transaction has crossed a 4KB boundary. | A3.4.1 |
| AXI4-60003 | AXI4_ARADDR_CHANGED_BEFORE_ARREADY | The value of *ARADDR* has changed from its initial value between the time *ARVALID* was asserted and before *ARREADY* was asserted. | A3.2.1 |
| AXI4-60004 | AXI4_ARADDR_FALLS_IN_REGION_HOLE | The *ARADDR* value cannot be decoded to a region in the region map. | A8.2.1 |
| AXI4-60005 | AXI4_ARADDR_UNKN | *ARADDR* has an X value/*ARADDR* has a Z value. | |
| AXI4-60006 | AXI4_ARBURST_CHANGED_BEFORE_ARREADY | The value of *ARBURST* has changed from its initial value between the time *ARVALID* was asserted and before *ARREADY* was asserted. | A3.2.1 |
| AXI4-60007 | AXI4_ARBURST_UNKN | *ARBURST* has an X value/*ARBURST* has a Z value. | |
| AXI4-60008 | AXI4_ARCACHE_CHANGED_BEFORE_ARREADY | The value of *ARCACHE* has changed from its initial value between the time *ARVALID* was asserted and before *ARREADY* was asserted. | A3.2.1 |
| AXI4-60009 | AXI4_ARCACHE_UNKN | *ARCACHE* has an X value/*ARCACHE* has a Z value. | |
| AXI4-60010 | AXI4_ARID_CHANGED_BEFORE_ARREADY | The value of *ARID* has changed from its initial value between the time *ARVALID* was asserted and before *ARREADY* was asserted. | A3.2.1 |
| AXI4-60011 | AXI4_ARID_UNKN | *ARID* has an X value/*ARID* has a Z value. | |

**Table A-2. AXI4 Assertions**

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI4-60012 | AXI4_ARLEN_CHANGED_BEFORE_ARREADY | The value of *ARLEN* has changed from its initial value between the time *ARVALID* was asserted and before *ARREADY* was asserted. | A3.2.1 |
| AXI4-60013 | AXI4_ARLEN_UNKN | *ARLEN* has an X value/*ARLEN* has a Z value. | |
| AXI4-60014 | AXI4_ARLOCK_CHANGED_BEFORE_ARREADY | The value of *ARLOCK* has changed from its initial value between the time *ARVALID* was asserted and before *ARREADY* was asserted. | A3.2.1 |
| AXI4-60015 | AXI4_ARLOCK_UNKN | *ARLOCK* has an X value/ARLOCK has a Z value. | |
| AXI4-60016 | AXI4_ARPROT_CHANGED_BEFORE_ARREADY | The value of *ARPROT* has changed from its initial value between the time *ARVALID* was asserted and before *ARREADY* was asserted. | A3.2.1 |
| AXI4-60017 | AXI4_ARPROT_UNKN | *ARPROT* has an X value/*ARPROT* has a Z value. | |
| AXI4-60018 | AXI4_ARQOS_CHANGED_BEFORE_ARREADY | The value of *ARQOS* has changed from its initial value between the time *ARVALID* was asserted and before *ARREADY* was asserted. | A3.2.1 |
| AXI4-60019 | AXI4_ARQOS_UNKN | *ARQOS* has an X value/*ARQOS* has a Z value. | |
| AXI4-60020 | AXI4_ARREADY_NOT_ASSERTED_AFTER_ARVALID | Once *ARVALID* has been asserted *ARREADY* should be asserted in *config_max_latency_ARVALID_assertion_to_ARREADY* clock periods. | |
| AXI4-60021 | AXI4_ARREADY_UNKN | *ARREADY* has an X value/*ARREADY* has a Z value. | |
| AXI4-60022 | AXI4_ARREGION_CHANGED_BEFORE_ARREADY | The value of *ARREGION* has changed from its initial value between the time *ARVALID* was asserted and before *ARREADY* was asserted. | A3.2.1 |
| AXI4-60023 | AXI4_ARREGION_MISMATCH | The *ARREGION* value does not match the value defined in the region map. | A8.2.1 |
| AXI4-60024 | AXI4_ARREGION_UNKN | *ARREGION* has an X value/*ARREGION* has a Z value. | |
| AXI4-60025 | AXI4_ARSIZE_CHANGED_BEFORE_ARREADY | The value of *ARSIZE* has changed from its initial value between the time *ARVALID* was asserted and before *ARREADY* was asserted. | A3.2.1 |
| AXI4-60026 | AXI4_ARSIZE_UNKN | *ARSIZE* has an X value/*ARSIZE* has a Z value. | |

## Table A-2. AXI4 Assertions

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI4-60027 | AXI4_ARUSER_CHANGED_BEFORE_ARREADY | The value of *ARUSER* has changed from its initial value between the time *ARVALID* was asserted and before *ARREADY* was asserted. | A3.2.1 |
| AXI4-60028 | AXI4_ARUSER_UNKN | *ARUSER* has an X value/*ARUSER* has a Z value. | |
| AXI4-60029 | AXI4_ARVALID_DEASSERTED_BEFORE_ARREADY | *ARVALID* has been de-asserted before *ARREADY* was asserted. | A3.2.1 |
| AXI4-60030 | AXI4_ARVALID_HIGH_ON_FIRST_CLOCK | A master interface must begin driving *ARVALID* high only at a rising clock edge after *ARESETn* is *HIGH*. | A3.1.2 |
| AXI4-60031 | AXI4_ARVALID_UNKN | *ARVALID* has an X value/*ARVALID* has a Z value. | |
| AXI4-60032 | AXI4_AWADDR_CHANGED_BEFORE_AWREADY | The value of *AWADDR* has changed from its initial value between the time *AWVALID* was asserted and before *AWREADY* was asserted. | A3.2.1 |
| AXI4-60033 | AXI4_AWADDR_FALLS_IN_REGION_HOLE | The addr value cannot be decoded to a region in the region map. | A8.2.1 |
| AXI4-60034 | AXI4_AWADDR_UNKN | *AWADDR* has an X value/*AWADDR* has a Z value. | |
| AXI4-60035 | AXI4_AWBURST_CHANGED_BEFORE_AWREADY | The value of *AWBURST* has changed from its initial value between the time *AWVALID* was asserted and before *AWREADY* was asserted. | A3.2.1 |
| AXI4-60036 | AXI4_AWBURST_UNKN | *AWBURST* has an X value/*AWBURST* has a Z value. | |
| AXI4-60037 | AXI4_AWCACHE_CHANGED_BEFORE_AWREADY | The value of *AWCACHE* has changed from its initial value between the time *AWVALID* was asserted and before *AWREADY* was asserted. | A3.2.1 |
| AXI4-60038 | AXI4_AWCACHE_UNKN | *AWCACHE* has an X value/*AWCACHE* has a Z value. | |
| AXI4-60039 | AXI4_AWID_CHANGED_BEFORE_AWREADY | The value of *AWID* has changed from its initial value between the time *AWVALID* was asserted and before *AWREADY* was asserted. | A3.2.1 |
| AXI4-60040 | AXI4_AWID_UNKN | *AWID* has an X value/*AWID* has a Z value. | |
| AXI4-60041 | AXI4_AWLEN_CHANGED_BEFORE_AWREADY | The value of *AWLEN* has changed from its initial value between the time *AWVALID* was asserted and before *AWREADY* was asserted. | A3.2.1 |

**Table A-2. AXI4 Assertions**

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI4-60042 | AXI4_AWLEN_UNKN | *AWLEN* has an X value/*AWLEN* has a Z value. | |
| AXI4-60043 | AXI4_AWLOCK_CHANGED_BEFORE_AWREADY | The value of *AWLOCK* has changed from its initial value between the time *AWVALID* was asserted and before *AWREADY* was asserted. | A3.2.1 |
| AXI4-60044 | AXI4_AWLOCK_UNKN | *AWLOCK* has an X value/*AWLOCK* has a Z value. | |
| AXI4-60045 | AXI4_AWPROT_CHANGED_BEFORE_AWREADY | The value of *AWPROT* has changed from its initial value between the time *AWVALID* was asserted and before *AWREADY* was asserted. | A3.2.1 |
| AXI4-60046 | AXI4_AWPROT_UNKN | *AWPROT* has an X value/*AWPROT* has a Z value. | |
| AXI4-60047 | AXI4_AWQOS_CHANGED_BEFORE_AWREADY | The value of *AWQOS* has changed from its initial value between the time *AWVALID* was asserted and before *AWREADY* was asserted. | A3.2.1 |
| AXI4-60048 | AXI4_AWQOS_UNKN | *AWQOS* has an X value/*AWQOS* has a Z value. | |
| AXI4-60049 | AXI4_AWREADY_NOT_ASSERTED_AFTER_AWVALID | Once *AWVALID* has been asserted AWREADY should be asserted in *config_max_latency_AWVALID_assertion_to_AWREADY* clock periods. | |
| AXI4-60050 | AXI4_AWREADY_UNKN | *AWREADY* has an X value/*AWREADY* has a Z value. | |
| AXI4-60051 | AXI4_AWREGION_CHANGED_BEFORE_AWREADY | The value of *AWREGION* has changed from its initial value between the time *AWVALID* was asserted and before *AWREADY* was asserted. | A3.2.1 |
| AXI4-60052 | AXI4_AWREGION_MISMATCH | The *AWREGION* value does not match the value defined in the region map. | A8.2.1 |
| AXI4-60053 | AXI4_AWREGION_UNKN | *AWREGION* has an X value/*AWREGION* has a Z value. | |
| AXI4-60054 | AXI4_AWSIZE_CHANGED_BEFORE_AWREADY | The value of *AWSIZE* has changed from its initial value between the time *AWVALID* was asserted and before *AWREADY* was asserted. | A3.2.1 |
| AXI4-60055 | AXI4_AWSIZE_UNKN | *AWSIZE* has an X value/A*WSIZE* has a Z value. | |

**Table A-2. AXI4 Assertions**

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI4-60056 | AXI4_AWUSER_CHANGED_BEFORE_AWREADY | The value of *AWUSER* has changed from its initial value between the time *AWVALID* was asserted and before *AWREADY* was asserted. | A3.2.1 |
| AXI4-60057 | AXI4_AWUSER_UNKN | *AWUSER* has an X value/*AWUSER* has a Z value. | |
| AXI4-60058 | AXI4_AWVALID_DEASSERTED_BEFORE_AWREADY | *AWVALID* has been de-asserted before *AWREADY* was asserted. | A3.2.1 |
| AXI4-60059 | AXI4_AWVALID_HIGH_ON_FIRST_CLOCK | A master interface must begin driving *AWVALID* high only at a rising clock edge after *ARESETn* is *HIGH*. | A3.1.2 |
| AXI4-60060 | AXI4_AWVALID_UNKN | *AWVALID* has an X value/*AWVALID* has a Z value. | |
| AXI4-60061 | AXI4_BID_CHANGED_BEFORE_BREADY | The value of *BID* has changed from its initial value between the time *BVALID* was asserted and before *BREADY* was asserted. | A3.2.1 |
| AXI4-60062 | AXI4_BID_UNKN | *BID* has an X value/*BID* has a Z value. | |
| AXI4-60063 | AXI4_BREADY_NOT_ASSERTED_AFTER_BVALID | Once *BVALID* has been asserted *BREADY* should be asserted in c*onfig_max_latency_BVALID_assertion_to_BREADY* clock periods. | |
| AXI4-60064 | AXI4_BREADY_UNKN | *BREADY* has an X value/*BREADY* has a Z value. | |
| AXI4-60065 | AXI4_BRESP_CHANGED_BEFORE_BREADY | The value of *BRESP* has changed from its initial value between the time *BVALID* was asserted and before *BREADY* was asserted. | A3.2.1 |
| AXI4-60066 | AXI4_BRESP_UNKN | *BRESP* has an X value/*BRESP* has a Z value. | |
| AXI4-60067 | AXI4_BUSER_CHANGED_BEFORE_BREADY | The value of *BUSER* has changed from its initial value between the time *BVALID* was asserted and before *BREADY* was asserted. | A3.2.1 |
| AXI4-60068 | AXI4_BUSER_UNKN | *BUSER* has an X value/*BUSER* has a Z value. | |
| AXI4-60069 | AXI4_BVALID_DEASSERTED_BEFORE_BREADY | *BVALID* has been de-asserted before *BREADY* was asserted. | A3.2.1 |
| AXI4-60070 | AXI4_BVALID_HIGH_EXITING_RESET | *BVALID* should have been driven low when exiting reset. | A3.1.2 |
| AXI4-60071 | AXI4_BVALID_UNKN | *BVALID* has an X value/*BVALID* has a Z value. | |

**Table A-2. AXI4 Assertions**

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI4-60072 | AXI4_DEC_ERR_RESP_FOR_READ | No slave at the address for this read transfer (signalled by *AXI4_DECERR*). | |
| AXI4-60073 | AXI4_DEC_ERR_RESP_FOR_WRITE | No slave at the address for this write transfer (signalled by *AXI4_DECERR*). | |
| AXI4-60074 | AXI4_EXCLUSIVE_READ_ACCESS_MODIFIABLE | The modifiable bit (bit 1 of the cache parameter) should not be set for an exclusive read access. | A7.2.4 |
| AXI4-60075 | AXI4_EXCLUSIVE_READ_BYTES_TRANSFER_EXCEEDS_128 | Number of bytes in an exclusive read transaction must be less than or equal to 128. | A7.2.4 |
| AXI4-60076 | AXI4_EXCLUSIVE_READ_BYTES_TRANSFER_NOT_POWER_OF_2 | Number of bytes of an exclusive read transaction is not a power of 2. | A7.2.4 |
| AXI4-60077 | AXI4_EXCLUSIVE_READ_LENGTH_EXCEEDS_16 | Exclusive read accesses are not permitted to use a burst length greater than 16. | A7.2.4 |
| AXI4-60078 | AXI4_EXCLUSIVE_WR_ADDRESS_NOT_SAME_AS_RD | Exclusive write does not match the address of the previous exclusive read to this id. | A7.2.4 |
| AXI4-60079 | AXI4_EXCLUSIVE_WR_BURST_NOT_SAME_AS_RD | Exclusive write does not match the burst setting of the previous exclusive read to this id. | A7.2.4 |
| AXI4-60080 | AXI4_EXCLUSIVE_WR_CACHE_NOT_SAME_AS_RD | Exclusive write does not match the cache setting of the previous exclusive read to this id (see the *ARM AXI4 compliance-checker AXI4_RECM_EXCL_MATCH* assertion code). | |
| AXI4-60081 | AXI4_EXCLUSIVE_WRITE_ACCESS_MODIFIABLE | The modifiable bit (bit 1 of the cache parameter) should not be set for an exclusive write access. | A7.2.4 |
| AXI4-60082 | AXI4_EXCLUSIVE_WR_LENGTH_NOT_SAME_AS_RD | Exclusive write does not match the length of the previous exclusive read to this id. | A7.2.4 |
| AXI4-60083 | AXI4_EXCLUSIVE_WR_PROT_NOT_SAME_AS_RD | Exclusive write does not match the prot setting of the previous exclusive read to this id. | A7.2.4 |
| AXI4-60084 | AXI4_EXCLUSIVE_WR_REGION_NOT_SAME_AS_RD | Exclusive write does not match the region setting of the previous exclusive read to this id. | A7.2.4 |
| AXI4-60085 | AXI4_EXCLUSIVE_WR_SIZE_NOT_SAME_AS_RD | Exclusive write does not match the size of the previous exclusive read to this id. | A7.2.4 |

## Table A-2. AXI4 Assertions

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI4-60086 | AXI4_EXOKAY_RESPONSE_NORMAL_READ | Slave has responded *AXI4_EXOKAY* to a non exclusive read transfer. | |
| AXI4-60087 | AXI4_EXOKAY_RESPONSE_NORMAL_WRITE | Slave has responded *AXI4_EXOKAY* to a non exclusive write transfer. | |
| AXI4-60088 | AXI4_EX_RD_EXOKAY_RESP_EXPECTED_OKAY | Expected *AXI4_OKAY* response to this exclusive read (because the parameters did not meet the the restrictions) but got *AXI4_EXOKAY*. | A7.2.4 |
| AXI4-60089 | AXI4_EX_RD_EXOKAY_RESP_SLAVE_WITHOUT_EXCLUSIVE_ACCESS | Response for an exclusive read to a slave which does not support exclusive access should be *AXI4_OKAY* but it returned *AXI4_EXOKAY*. | A7.2.5 |
| AXI4-60090 | AXI4_EX_RD_OKAY_RESP_EXPECTED_EXOKAY | Expected *AXI4_EXOKAY* response to this exclusive read (because the parameters met the restrictions) but got *AXI4_OKAY*. | A7.2.4 |
| AXI4-60091 | AXI4_EX_RD_WHEN_EX_NOT_ENABLED | An exclusive read should not be issued when exclusive transactions are not enabled. | |
| AXI4-60092 | AXI4_EX_WRITE_BEFORE_EX_READ_RESPONSE | Exclusive write has occurred with no previous exclusive read. | |
| AXI4-60093 | AXI4_EX_WRITE_EXOKAY_RESP_EXPECTED_OKAY | Exclusive write has not been successful but slave has responded with *AXI4_EXOKAY*. | A7.2.2 |
| AXI4-60094 | AXI4_EX_WRITE_EXOKAY_RESP_SLAVE_WITHOUT_EXCLUSIVE_ACCESS | Response for an exclusive write to a slave which does not support exclusive access should be *AXI4_OKAY* but it returned *AXI4_EXOKAY*. | A7.2.5 |
| AXI4-60095 | AXI4_EX_WRITE_OKAY_RESP_EXPECTED_EXOKAY | An *AXI4_OKAY* response to an exclusive write occurred but an *AXI4_EXOKAY* response had been expected. If the slave has multiple interfaces to the system this check should be disabled as it is possible for this response to occur as a result of activity on another port. | A7.2.2 |
| AXI4-60096 | AXI4_EX_WR_WHEN_EX_NOT_ENABLED | An exclusive write should not be issued when exclusive transactions are not enabled. | |
| AXI4-60097 | AXI4_ILLEGAL_ARCACHE_VALUE_FOR_CACHEABLE_ADDRESS_REGION | For a read from a cacheable address region one of bits 2 or 3 of the cache parameter must be *HIGH*. | A4.5 |

**Table A-2. AXI4 Assertions**

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI4-60098 | AXI4_ILLEGAL_ARCACHE_VALUE_FOR_NON_CACHEABLE_ADDRESS_REGION | For a read from a non-cacheable address region bits 2 and 3 of the cache parameter must be *LOW*. | A4.5 |
| AXI4-60099 | AXI4_ILLEGAL_AWCACHE_VALUE_FOR_CACHEABLE_ADDRESS_REGION | For a write to a cacheable address region one of bits 2 or 3 of the cache parameter must be *HIGH*. | A4.5 |
| AXI4-60100 | AXI4_ILLEGAL_AWCACHE_VALUE_FOR_NON_CACHEABLE_ADDRESS_REGION | For a write to a non-cacheable address region bits 2 and 3 of the cache parameter must be *LOW*. | A4.5 |
| AXI4-60101 | AXI4_ILLEGAL_LENGTH_FIXED_READ_BURST | In the last read address phase *burst_length* has an illegal value for a burst of type *AXI4_FIXED* | A3.4.1 |
| AXI4-60102 | AXI4_ILLEGAL_LENGTH_FIXED_WRITE_BURST | In the last write address phase burst_length has an illegal value for a burst of type *AXI4_FIXED* | A3.4.1 |
| AXI4-60103 | AXI4_ILLEGAL_LENGTH_WRAPPING_READ_BURST | In the last read address phase burst_length has an illegal value for a burst of type AXI4_WRAP | A3.4.1 |
| AXI4-60104 | AXI4_ILLEGAL_LENGTH_WRAPPING_WRITE_BURST | In the last write address phase burst_length has an illegal value for a burst of type AXI4_WRAP | A3.4.1 |
| AXI4-60105 | AXI4_ILLEGAL_RESPONSE_EXCLUSIVE_READ | Response for an exclusive read should be either *AXI4_OKAY* or *AXI4_EXOKAY*. | |
| AXI4-60106 | AXI4_ILLEGAL_RESPONSE_EXCLUSIVE_WRITE | Response for an exclusive write should be either *AXI4_OKAY* or *AXI4_EXOKAY*. | |
| AXI4-60107 | AXI4_INVALID_REGION_CARDINALITY | The configuration parameter *config_slave_regions* does not lie in the range 1-16 inclusive | A8.2.1. |
| AXI4-60108 | AXI4_INVALID_WRITE_STROBES_ON_ALIGNED_WRITE_TRANSFER | Write strobe(s) incorrect for address/size of an aligned transaction | A3.4.3 |
| AXI4-60109 | AXI4_INVALID_WRITE_STROBES_ON_UNALIGNED_WRITE_TRANSFER | Write strobe(s) incorrect for address/size of an unaligned transaction | A3.4.3 |
| AXI4-60110 | AXI4_MINIMUM_SLAVE_ADDRESS_SPACE_VIOLATION | The minimum address space occupied by a single slave device is 4 kilobytes | A10.3.2 |
| AXI4-60111 | AXI4_NON_INCREASING_REGION_SPECIFICATION | A region address-range has an upper bound smaller than the lower bound. | |
| AXI4-60112 | AXI4_NON_ZERO_ARQOS | The master is configured to not participate in the Quality-of-Service scheme but A*RQOS* is not 4'b0000 as it should be | A8.1.2 |

**Table A-2. AXI4 Assertions**

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI4-60113 | AXI4_NON_ZERO_AWQOS | The master is configured to not participate in the Quality-of-Service scheme but *AWQOS* is not 4'b0000 as it should be | A8.1.2 |
| AXI4-60114 | AXI4_OVERLAPPING_REGION | An address-range in the region map overlaps with another address in the region map | A8.2.1. |
| AXI4-60115 | AXI4_PARAM_READ_DATA_BUS_WIDTH | The value of *AXI4_RDATA_WIDTH* must be one of 8,16,32,64,128,256,512, or 1024 | A1.3.1 |
| AXI4-60116 | AXI4_PARAM_READ_REORDERING_DEPTH_EQUALS_ZERO | The user-supplied *config_read_data_reordering_depth* should be greater than zero | A5.3.1 |
| AXI4-60117 | AXI4_PARAM_READ_REORDERING_DEPTH_EXCEEDS_MAX_ID | The user-supplied *config_read_data_reordering_depth* exceeds the maximum possible value as defined by the *AXI4_ID_WIDTH* parameter | A5.3.1 |
| AXI4-60118 | AXI4_PARAM_WRITE_DATA_BUS_WIDTH | The value of *AXI4_WDATA_WIDTH* must be one of 8,16,32,64,128,256,512, or 1024 | A1.3.1 |
| AXI4-60119 | AXI4_READ_ALLOCATE_WHEN_NON_MODIFIABLE_12 | The *RA* bit of the cache parameter should not be *HIGH* when the Modifiable bit is *LOW* | A4.4 |
| AXI4-60120 | AXI4_READ_ALLOCATE_WHEN_NON_MODIFIABLE_13 | The *RA* bit of the cache parameter should not be *HIGH* when the Modifiable bit is *LOW* | A4.4 |
| AXI4-60121 | AXI4_READ_ALLOCATE_WHEN_NON_MODIFIABLE_4 | The *RA* of the cache parameter bit should not be *HIGH* when the Modifiable bit is *LOW* | A4.4 |
| AXI4-60122 | AXI4_READ_ALLOCATE_WHEN_NON_MODIFIABLE_5 | The *RA* of the cache parameter bit should not be *HIGH* when the Modifiable bit is *LOW* | A4.4 |
| AXI4-60123 | AXI4_READ_ALLOCATE_WHEN_NON_MODIFIABLE_8 | The *RA* of the cache parameter bit should not be *HIGH* when the Modifiable bit is *LOW* | A4.4 |
| AXI4-60124 | AXI4_READ_ALLOCATE_WHEN_NON_MODIFIABLE_9 | The *RA* of the cache parameter bit should not be *HIGH* when the Modifiable bit is *LOW* | A4.4 |
| AXI4-60125 | AXI4_READ_BURST_LENGTH_VIOLATION | The *burst_length* implied by the number of beats actually read does not match the *burst_length* defined by the *master_read_addr_channel_phase*. | |
| AXI4-60126 | AXI4_READ_BURST_MAXIMUM_LENGTH_VIOLATION | 256 read data beats were seen without *RLAST* | A3.4.1 |

**Table A-2. AXI4 Assertions**

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI4-60127 | AXI4_READ_BURST_SIZE_VIOLATION | In this read transaction, size has been set too high for the defined data buswidth. | |
| AXI4-60128 | AXI4_READ_DATA_BEFORE_ADDRESS | An unexpected read response has occurred (there are no outstanding read transactions with this id). | A3.3.1 |
| AXI4-60129 | AXI4_READ_DATA_CHANGED_BEFORE_RREADY | The value of *RDATA* has changed from its initial value between the time *RVALID* was asserted and before *RREADY* was asserted. | A3.2.1 |
| AXI4-60130 | AXI4_READ_DATA_UNKN | *RDATA* has an X value/*RDATA* has a Z value. | |
| AXI4-60131 | AXI4_READ_EXCLUSIVE_ENCODING_VIOLATION. | A read-only interface does not support exclusive accesses. | A10.2.2 |
| AXI4-60132 | AXI4_READ_REORDERING_VIOLATION | The arrival of a read response has exceeded the read reordering depth. | A5.3.1 |
| AXI4-60133 | AXI4_READ_RESP_CHANGED_BEFORE_RREADY | The value of *RRESP* has changed from its initial value between the time *RVALID* was asserted and before *RREADY* was asserted. | A3.2.1 |
| AXI4-60134 | AXI4_READ_TRANSFER_EXCEEDS_ADDRESS_SPACE | This read transfer runs off the edge of the address space defined by *AXI4_ADDRESS_WIDTH*. | A10.3.1 |
| AXI4-60135 | AXI4_REGION_SMALLER_THAN_4KB | An address-range in the region map is smaller than 4kB. | A8.2.1 |
| AXI4-60136 | AXI4_RESERVED_ARBURST_ENCODING | The reserved encoding of 2'b11 should not be used for *ARBURST*. | A3.4.1 |
| AXI4-60137 | AXI4_RESERVED_AWBURST_ENCODING | The reserved encoding of 2'b11 should not be used for *AWBURST*. | A3.4.1 |
| AXI4-60138 | AXI4_RID_CHANGED_BEFORE_RREADY | The value of *RID* has changed from its initial value between the time *RVALID* was asserted and before *RREADY* was asserted. | A3.2.1 |
| AXI4-60139 | AXI4_RID_UNKN | RID has an X value/*RID* has a Z value. | |
| AXI4-60140 | AXI4_RLAST_CHANGED_BEFORE_RREADY | The value of *RLAST* has changed from its initial value between the time *RVALID* was asserted and before *RREADY* was asserted. | A3.2.1 |
| AXI4-60141 | AXI4_RLAST_UNKN | *RLAST* has an X value/*RLAST* has a Z value. | |
| AXI4-60142 | AXI4_RREADY_NOT_ASSERTED_AFTER_RVALID | Once *RVALID* has been asserted *RREADY* should be asserted in *config_max_latency_RVALID_assertion_to_RREADY* clock periods. | |

**Table A-2. AXI4 Assertions**

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI4-60143 | AXI4_RREADY_UNKN | *RREADY* has an X value/RREADY has a Z value. | |
| AXI4-60144 | AXI4_RRESP_UNKN | *RRESP* has an X value/*RRESP* has a Z value. | |
| AXI4-60145 | AXI4_RUSER_CHANGED_BEFORE_RREADY | The value of *RUSER* has changed from its initial value between the time *RVALID* was asserted and before *RREADY* was asserted. | A3.2.1 |
| AXI4-60146 | AXI4_RUSER_UNKN | *RUSER* has an X value/*RUSER* has a Z value. | |
| AXI4-60147 | AXI4_RVALID_DEASSERTED_BEFORE_RREADY | *RVALID* has been de-asserted before *RREADY* was asserted. | A3.2.1 |
| AXI4-60148 | AXI4_RVALID_HIGH_EXITING_RESET | *RVALID* should have been driven low when exiting reset. | A3.1.2 |
| AXI4-60149 | AXI4_RVALID_UNKN | *RVALID* has an X value/*RVALID* has a Z value. | |
| AXI4-60150 | AXI4_SLV_ERR_RESP_FOR_READ | Slave has detected an error for this read transfer (signalled by *AXI4_SLVERR)* | |
| AXI4-60151 | AXI4_SLV_ERR_RESP_FOR_WRITE | Slave has detected an error for this write transfer (signalled by *AXI4_SLVERR*) | |
| AXI4-60152 | AXI4_TIMEOUT_WAITING_FOR_READ_RESPONSE | Timed-out waiting for a read response. | A4.6 |
| AXI4-60153 | AXI4_TIMEOUT_WAITING_FOR_WRITE_RESPONSE | Timed-out waiting for a write response. | A4.6 |
| AXI4-60154 | AXI4_UNALIGNED_ADDRESS_FOR_EXCLUSIVE_READ | Exclusive read accesses must have address aligned to the total number of bytes in the transaction. | A7.2.4 |
| AXI4-60155 | AXI4_UNALIGNED_ADDR_FOR_WRAPPING_READ_BURST | Wrapping bursts must have address aligned to the start of the read transfer. | A3.4.1 |
| AXI4-60156 | AXI4_UNALIGNED_ADDR_FOR_WRAPPING_WRITE_BURST | Wrapping bursts must have address aligned to the start of the write transfer. | A3.4.1 |
| AXI4-60157 | AXI4_WDATA_CHANGED_BEFORE_WREADY_ON_INVALID_LANE | On a lane whose strobe is 0, the value of *WDATA* has changed from its initial value between the time *WVALID* was asserted and before *WREADY* was asserted. | A3.2.1 |
| AXI4-60158 | AXI4_WDATA_CHANGED_BEFORE_WREADY_ON_VALID_LANE | On a lane whose strobe is 1, the value of *WDATA* has changed from its initial value between the time *WVALID* was asserted and before *WREADY* was asserted. | A3.2.1 |

## Table A-2. AXI4 Assertions

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI4-60159 | AXI4_WLAST_CHANGED_BEFORE_WREADY | The value of *WLAST* has changed from its initial value between the time *WVALID* was asserted and before *WREADY* was asserted. | A3.2.1 |
| AXI4-60160 | AXI4_WLAST_UNKN | *WLAST* has an X value/W*LAST* has a Z value. | |
| AXI4-60161 | AXI4_WREADY_NOT_ASSERTED_AFTER_WVALID | Once *WVALID* has been asserted *WREADY* should be asserted in *config_max_latency_WVALID_assertion_to_WREADY* clock periods. | |
| AXI4-60062 | AXI4_WREADY_UNKN | *WREADY* has an X value/*WREADY* has a Z value. | |
| AXI4-60163 | AXI4_WRITE_ALLOCATE_WHEN_NON_MODIFIABLE_12 | The WA bit of the cache parameter should not be *HIGH* when the Modifiable bit is *LOW*. | A4.4 |
| AXI4-60164 | AXI4_WRITE_ALLOCATE_WHEN_NON_MODIFIABLE_13 | The *WA* of the cache parameter bit should not be *HIGH* when the Modifiable bit is *LOW*. | A4.4 |
| AXI4-60165 | AXI4_WRITE_ALLOCATE_WHEN_NON_MODIFIABLE_4 | The *WA* of the cache parameter bit should not be *HIGH* when the Modifiable bit is *LOW*. | A4.4 |
| AXI4-60166 | AXI4_WRITE_ALLOCATE_WHEN_NON_MODIFIABLE_5 | The *WA* of the cache parameter bit should not be *HIGH* when the Modifiable bit is *LOW*. | A4.4 |
| AXI4-60167 | AXI4_WRITE_ALLOCATE_WHEN_NON_MODIFIABLE_8 | The *WA* of the cache parameter bit should not be *HIGH* when the Modifiable bit is *LOW*. | A4.4 |
| AXI4-60168 | AXI4_WRITE_ALLOCATE_WHEN_NON_MODIFIABLE_9 | The *WA* of the cache parameter bit should not be *HIGH* when the Modifiable bit is *LOW*. | A4.4 |
| AXI4-60169 | AXI4_WRITE_BURST_LENGTH_VIOLATION | The number of data beats in a write transfer should match the value given by *AWLEN*. | |
| AXI4-60170 | AXI4_WRITE_STROBES_LENGTH_VIOLATION | The size of the write_strobes array in a write transfer should match the value given by *AWLEN*. | |
| AXI4-60171 | AXI4_WRITE_USER_DATA_LENGTH_VIOLATION | The size of the wdata_user_data array in a write transfer should match the value given by *AWLEN*. | |
| AXI4-60172 | AXI4_WRITE_BURST_MAXIMUM_LENGTH_VIOLATION | 256 write data beats were seen without *WLAST*. | A3.4.1 |
| AXI4-60173 | AXI4_WRITE_BURST_SIZE_VIOLATION | In this write transaction size has been set too high for the defined data buswidth. | |

**Table A-2. AXI4 Assertions**

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI4-60174 | AXI4_WRITE_DATA_BEFORE_ ADDRESS | A write data beat has occurred before the corresponding address phase. | |
| AXI4-60175 | AXI4_WRITE_DATA_UNKN_ON_INVALID_ LANE | On a lane whose strobe is 0 *WDATA* has an X value/*WDATA* has a Z value. | |
| AXI4-60176 | AXI4_WRITE_DATA_UNKN_ON_VALID_LANE | On a lane whose strobe is 1 *WDATA* has an X value/*WDATA* has a Z value. | |
| AXI4-60177 | AXI4_WRITE_EXCLUSIVE_ENCODING_ VIOLATION | A write-only interface does not support exclusive accesses. | A10.2.3 |
| AXI4-60178 | AXI4_WRITE_RESPONSE_WITHOUT_ ADDR_DATA | An unexpected write response has occurred (there are no outstanding write transactions with this id). | |
| AXI4-60179 | AXI4_WRITE_STROBE_FIXED_BURST_ VIOLATION | Write strobe(s) incorrect for the address/size of a fixed transfer. | |
| AXI4-60180 | AXI4_WRITE_TRANSFER_EXCEEDS_ ADDRESS_SPACE | This write transfer runs off the edge of the address space defined by *AXI4_ADDRESS_WIDTH*. | A10.3.1 |
| AXI4-60181 | AXI4_WRONG_ARREGION_FOR_SLAVE_ WITH_SINGLE_ADDRESS_ DECODE | The region value should be 4'b0000 for a read from a slave with a single address decode in the region map. | A8.2.1 |
| AXI4-60182 | AXI4_WRONG_AWREGION_FOR_SLAVE_ WITH_SINGLE_ADDRESS_ DECODE | The region value should be 4'b0000 for a write to a slave with a single address decode in the region map. | A8.2.1 |
| AXI4-60183 | AXI4_WSTRB_CHANGED_BEFORE_ WREADY | The value of *WSTRB* has changed from its initial value between the time *WVALID* was asserted and before *WREADY* was asserted. | A3.2.1 |
| AXI4-60184 | AXI4_WSTRB_UNKN | *WSTRB* has an X value/*WSTRB* has a Z value. | |
| AXI4-60185 | AXI4_WUSER_CHANGED_BEFORE_ WREADY | The value of *WUSER* has changed from its initial value between the time *WVALID* was asserted and before *WREADY* was asserted. | A3.2.1 |
| AXI4-60186 | AXI4_WUSER_UNKN | *WUSER* has an X value/*WUSER* has a Z value. | |
| AXI4-60187 | AXI4_WVALID_DEASSERTED_BEFORE_ WREADY | *WVALID* has been de-asserted before *WREADY* was asserted. | A3.2.1 |
| AXI4-60188 | AXI4_WVALID_HIGH_ON_FIRST_CLOCK | A master interface must begin driving *WVALID* high only at a rising clock edge after *ARESETn* is *HIGH*. | A3.1.2 |
| AXI4-60189 | AXI4_WVALID_UNKN | *WVALID* has an X value/*WVALID* has a Z value. | |

**Table A-2. AXI4 Assertions**

| Error Code | Error Name | Description | Property Ref |
|---|---|---|---|
| AXI4-60190 | MVC_FAILED_POSTCONDITION | A postcondition failed. | |
| AXI4-60191 | MVC_FAILED_RECOGNITION | An item failed to be recognized. | |
| AXI4-60192 | AXI4_TIMEOUT_WAITING_FOR_WRITE_DATA | Timed-out waiting for a data phase in write data burst. | A4.6 |
| AXI4-60193 | AXI4_EXCL_RD_WHILE_EXCL_WR_IN_PROGRESS_SAME_ID | Master starts an exclusive read burst while exclusive write burst with same ID tag is in progress. | A7.2.4 |
| AXI4-60194 | AXI4_EXCL_WR_WHILE_EXCL_RD_IN_PROGRESS_SAME_ID | Master starts an exclusive write burst while exclusive read burst with same ID tag is in progress. | A7.2.4 |
| AXI4-60195 | AXI4_DEC_ERR_ILLEGAL_FOR_MAPPED_SLAVE_ADDR | Slave receives a burst to a mapped address but responds with *DECERR* (signalled by *AXI4_DECERR*). | A3.4.4 |

# Appendix B
# SystemVerilog AXI3 and AXI4 Test Programs

## SystemVerilog AXI3 Master BFM Test Program

The following code example contains a simple AXI3 master test program that shows the master BFM API being used to communicate with a slave and create stimulus. This test program is discussed further in the SystemVerilog Tutorials Chapter.

```
        //
        ******************************************************************
        //
        // Copyright 2007-2012 Mentor Graphics Corporation
        // All Rights Reserved.
        //
        // THIS WORK CONTAINS TRADE SECRET AND PROPRIETARY INFORMATION WHICH
        // IS THE PROPERTY OF MENTOR GRAPHICS CORPORATION OR ITS LICENSORS
        // AND IS SUBJECT TO LICENSE TERMS.
        //
        ******************************************************************

        /*
            This simplified example of an AXI master shows you how to use the
          mgc_axi_master BFM. This master performs a directed test, initiating
          four sequential writes, followed by four sequential reads. It then
          verifies that the data read out matches the data written.
              For simplicity, only one data cycle is used (default AXI burst
          length encoding 0). It then initiates two write data bursts,
          followed by two read data bursts.
          */

          import mgc_axi_pkg::*;
          module master_test_program #(int AXI_ADDRESS_WIDTH = 32, int
          AXI_RDATA_WIDTH = 1024, int AXI_WDATA_WIDTH = 1024, int AXI_ID_WIDTH
          = 4)
          (
      mgc_axi_master bfm
);

initial
begin
    axi_transaction trans;
    /******************
    ** Configuration **
    ******************/
    begin
      bfm.set_config(AXI_CONFIG_MAX_TRANSACTION_TIME_FACTOR, 1000);

end
```

```
    /*******************
    ** Initialization **
    *******************/
    bfm.wait_on(AXI_RESET_0_TO_1);
    bfm.wait_on(AXI_CLOCK_POSEDGE);

    /************************
    ** Traffic Generation: **
    ************************/
    // 4 x Writes
    // Write data value 1 on byte lanes 1 to address 1.
    trans = bfm.create_write_transaction(1);
    trans.set_data_words(32'h0000_0100, 0);
    trans.set_write_strobes(4'b0010, 0);
    $display ( "@ %t, master_test_program: Writing data (1) to address
(1)", $time);

    // By default it will run in Blocking mode
    bfm.execute_transaction(trans);

    // Write data value 2 on byte lane 2 to address 2.
    trans = bfm.create_write_transaction(2);
    trans.set_data_words(32'h0002_0000, 0);
    trans.set_write_strobes(4'b0100, 0);
    trans.set_write_data_mode(AXI_DATA_WITH_ADDRESS);
    $display ( "@ %t, master_test_program: Writing data (2) to address
(2)", $time);

    bfm.execute_transaction(trans);

    // Write data value 3 on byte lane 3 to address 3.
    trans = bfm.create_write_transaction(3);
    trans.set_data_words(32'h0300_0000, 0);
    trans.set_write_strobes(4'b1000, 0);
    $display ( "@ %t, master_test_program: Writing data (3) to address
(3)", $time);

    bfm.execute_transaction(trans);

    // Write data value 4 to address 4 on byte lane 0.
    trans = bfm.create_write_transaction(4);
    trans.set_data_words(32'h0000_0004, 0);
    trans.set_write_strobes(4'b0001, 0);
    trans.set_write_data_mode(AXI_DATA_WITH_ADDRESS);
    $display ( "@ %t, master_test_program: Writing data (4) to address
(4)", $time);

    bfm.execute_transaction(trans);

    // 4 x Reads
    // Read data from address 1.
    trans = bfm.create_read_transaction(1);
    trans.set_id(1);
```

```
    bfm.execute_transaction(trans);
    if (trans.get_data_words(0) == 32'h0000_0100)
        $display ( "@ %t, master_test_program: Read correct data (1) at
address (1)", $time);
    else
       $display ( "@ %t master_test_program: Expected data (1) at address
1, but got %d", $time, trans.get_data_words(0));

    // Read data from address 2.
    trans = bfm.create_read_transaction(2);
    trans.set_id(2);

    bfm.execute_transaction(trans);
    if (trans.get_data_words(0) == 32'h0002_0000)
        $display ( "@ %t, master_test_program: Read correct data (2) at
address (2)", $time);
    else
       $display ( "@ %t, master_test_program: Expected data (2) at address
2, but got %d", $time, trans.get_data_words(0));

    // Read data from address 3.
    trans = bfm.create_read_transaction(3);
    trans.set_id(3);

    bfm.execute_transaction(trans);
    if (trans.get_data_words(0) == 32'h0300_0000)
      $display ( "@ %t, master_test_program: Read correct data (3) at
address (3)", $time);
    else
       $display ( "@ %t, master_test_program: Expected data (3) at address
3, but got %d", $time, trans.get_data_words(0));

    // Read data from address 4.
    trans = bfm.create_read_transaction(4);
    trans.set_id(4);

    bfm.execute_transaction(trans);
    if (trans.get_data_words(0) == 32'h0000_0004)
        $display ( "@ %t, master_test_program: Read correct data (4) at
address (4)", $time);
    else
       $display ( "@ %t, master_test_program: Expected data (4) at address
4, but got %d", $time, trans.get_data_words(0));

    // Write data burst length of 7 to start address 16.
    trans = bfm.create_write_transaction(16, 7);

    trans.set_size(AXI_BYTES_4);
    trans.set_data_words('hACE0ACE1, 0);
    trans.set_data_words('hACE2ACE3, 1);
    trans.set_data_words('hACE4ACE5, 2);
    trans.set_data_words('hACE6ACE7, 3);
    trans.set_data_words('hACE8ACE9, 4);
    trans.set_data_words('hACEAACEB, 5);
    trans.set_data_words('hACECACED, 6);
    trans.set_data_words('hACEEACEF, 7);
    for(int i=0; i<8; i++)
              trans.set_write_strobes(4'b1111, i);
```

```
    trans.set_write_data_mode(AXI_DATA_WITH_ADDRESS);
    $display ( "@ %t, master_test_program: Writing data burst of length 7
to start address 16", $time);

    bfm.execute_transaction(trans);

    // Write data burst of length 7 to start address 128 with LSB write
    // strobe inactive.
    trans = bfm.create_write_transaction(128, 7);

    trans.set_size(AXI_BYTES_4);
    trans.set_data_words('hACE0ACE1, 0);
    trans.set_data_words('hACE2ACE3, 1);
    trans.set_data_words('hACE4ACE5, 2);
    trans.set_data_words('hACE6ACE7, 3);
    trans.set_data_words('hACE8ACE9, 4);
    trans.set_data_words('hACEAACEB, 5);
    trans.set_data_words('hACECACED, 6);
    trans.set_data_words('hACEEACEF, 7);

    trans.set_write_strobes(4'b1110, 0);
    for(int i=1; i<8; i++)
        trans.set_write_strobes(4'b1111, i);
    $display ( "@ %t, master_test_program: Writing data burst of length 7
to start address 128", $time);

    bfm.execute_transaction(trans);

    // Read data burst of length 1 from address 16.
    trans = bfm.create_read_transaction(16, 1);
    trans.set_size(AXI_BYTES_4);

    bfm.execute_transaction(trans);
    if (trans.get_data_words(0) == 'hACE0ACE1)
      $display ( "@ %t, master_test_program: Read correct data (hACE0ACE1)
at address (16)", $time);
    else
      $display ( "@ %t, master_test_program: Expected data (hACE0ACE1) at
address (16), but got %h", $time, trans.get_data_words(0));

    if (trans.get_data_words(1) == 'hACE2ACE3)
      $display ( "@ %t, master_test_program: Read correct data (hACE2ACE3)
at address (20)", $time);
    else
      $display ( "@ %t, master_test_program: Expected data (hACE2ACE3) at
address (20), but got %h", $time, trans.get_data_words(1));


    // Read data burst of length 1 from address 128.
    trans = bfm.create_read_transaction(128, 1);
    trans.set_size(AXI_BYTES_4);
```

```
    bfm.execute_transaction(trans);
    if (trans.get_data_words(0) == 'hACE0AC00)
      $display ( "@ %t, master_test_program: Read correct data (hACE0AC00)
at address (128)", $time);
    else
      $display ( "@ %t, master_test_program: Expected data (hACE0AC00) at
address (128), but got %h", $time, trans.get_data_words(0));

    if (trans.get_data_words(1) == 'hACE2ACE3)
      $display ( "@ %t, master_test_program: Read correct data (hACE2ACE3)
at address (132)", $time);
    else
      $display ( "@ %t, master_test_program: Expected data (hACE2ACE3) at
address (132), but got %h", $time, trans.get_data_words(1));

    #100
    $finish();
end
endmodule
```

# SystemVerilog AXI3 Slave BFM Test Program

The following code example contains a simple AXI3 slave test program that shows the slave BFM API being used to communicate with a master and create stimulus. This test program is discussed further in the SystemVerilog Tutorials Chapter.

```
//
********************************************************************************
//
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THE PROPERTY OF
// MENTOR GRAPHICS CORPORATION OR ITS LICENSORS AND IS SUBJECT TO LICENSE
TERMS.
//
//
********************************************************************************
This simple example of an AXI Slave demonstrates the mgc_axi_slave BFM
usage. This slave BFM can handle most write and read transaction scenarios
from the master, including a write data burst starting at the same time,
or after, its address phase.

/*
    This slave code is divided into two parts, one which the user edits to
change slave mode (Transaction/burst or Phase level)and memory handling.
    Code labeled in this example that the "Users normally need not edit
this code", sometimes requires the user to edit it, if the code must meet
required phase valid/ready delays.
*/
```

```
import mgc_axi_pkg::*;

module slave_test_program #(int AXI_ADDRESS_WIDTH = 32, int
AXI_RDATA_WIDTH = 32, int AXI_WDATA_WIDTH = 32, int AXI_ID_WIDTH = 4)
(
    mgc_axi_slave bfm
);

  typedef bit [((AXI_ADDRESS_WIDTH) - 1) : 0] addr_t;

  // Enum type for slave mode
  // AXI_TRANSACTION_SLAVE - Works at burst level (write data is received
at
  //                         burst and read data/response is sent in burst)
  // AXI_PHASE_SLAVE       - Write data and read data/response is worked
upon
  //                          at phase level
  typedef enum bit
  {
    AXI_TRANSACTION_SLAVE = 1'b0,
    AXI_PHASE_SLAVE       = 1'b1
  } axi_slave_mode_e;

  ////////////////////////////////////////////////
  // Users can edit the following code to meet requirements.
// For example:
// - Modify the default slave_mode configuration from
// AXI_TRANSACTION_SLAVE (buffered) to AXI_PHASE_SLAVE (unbuffered)
// for read/write data bursts.
// - Modify the default memory to a FIFO for FIXED transactions
// - Modify the delays of the *VALID and *READY signals to create
// a *READY active before *VALID active scenario
  ////////////////////////////////////////////////

  // Slave mode selection : default it is transaction level slave
  axi_slave_mode_e slave_mode = AXI_TRANSACTION_SLAVE;

  // Storage for a memory
  bit [7:0] mem [*];

  // Function: do_byte_read
  // Function provides read data byte from memory at particular input
  // address
  function bit[7:0] do_byte_read(addr_t addr);
    return mem[addr];
  endfunction

  // Function: do_byte_write
  // Function writes data byte to memory at particular input address
  function void do_byte_write(addr_t addr, bit [7:0] data);
    mem[addr] = data;
  endfunction

  // Function: set_write_address_ready_delay
  // This function sets and extends the write address phase ready delay
  function void set_write_address_ready_delay(axi_transaction trans);
    trans.set_address_ready_delay(2);
  endfunction
```

```
  // Function: set_read_address_ready_delay
  // This sets read address phase ready delay to extend the phase
  function void set_read_address_ready_delay(axi_transaction trans);
    trans.set_address_ready_delay(4);
  endfunction

  // Function: set_write_data_ready_delay
  // This function sets the ready delays for each write data phase in a
  //write data burst.
  function void set_write_data_ready_delay(axi_transaction trans);
    for (int i = 0; i < trans.data_ready_delay.size(); i++)
      trans.set_data_ready_delay(i, i);
  endfunction

  // Function: set_wr_resp_valid_delay
  // This sets write response phase valid delay to start driving the
  // write response phase after a specified delay.
  function void set_wr_resp_valid_delay(axi_transaction trans);
    trans.set_write_response_valid_delay(2);
  endfunction

  // Function: set_read_data_valid_delay
  // This sets read response phase valid delays to start driving the
  // read data/response phases after a specified delay.
  function void set_read_data_valid_delay(axi_transaction trans);
    for (int i = 0; i < trans.data_valid_delay.size(); i++)
      trans.set_data_valid_delay(i, i);
  endfunction


  ////////////////////////////////////////////////////////////////////////
  // Users normally need not edit this code.
  // The following code constitutes the Advanced Slave API.
  // You do not need to edit the following code unless you need to change
  // the AXI3 default response of OKAY
  //
 // This code also assigns the handshake signal delays for *VALID and
// *READY. You may want to change the default delays according to
// your own requirements. For example, to create a *READY active before
// *VALID active scenario.
//
  // address_ready_delay : This is for both write and read address phase
  // data_valid_delay    : This is for sending read data/response valid
  // data_ready_delay    : This is for write data phase ready delay
  ////////////////////////////////////////////////////////////////////////
  initial
  begin
    // Initialisation
    wait (bfm.ARESETn == 1);

    // Traffic generation
    fork
      process_read;
      process_write;
    join
  end
```

```
// Task: process_read
// This method continues to receive read address phase and calls
// another method to process the received transaction.
task process_read;
  forever
  begin
    axi_transaction read_trans;

    read_trans = bfm.create_slave_transaction();
    set_read_address_ready_delay(read_trans);
    bfm.get_read_addr_phase(read_trans);

    fork
      begin
        automatic axi_transaction t = read_trans;
        handle_read(t);
      end
    join_none
    #0;
  end
endtask

// Task: handle_read
// This method reads data from memory and sends the read data/response
// either at burst or phase level, based on the slave mode.
task automatic handle_read(input axi_transaction read_trans);
  addr_t addr[];
  bit [7:0] mem_data[];

  set_read_data_valid_delay(read_trans);

  for(int i = 0; bfm.get_read_addr(read_trans, i, addr); i++)
  begin
    mem_data = new[addr.size()];
    for (int j = 0; j < addr.size(); j++)
      mem_data[j] = do_byte_read(addr[j]);

    bfm.set_read_data(read_trans, i, addr, mem_data);

    if (slave_mode == AXI_PHASE_SLAVE)
      bfm.execute_read_data_phase(read_trans, i);
  end

  if (slave_mode == AXI_TRANSACTION_SLAVE)
    bfm.execute_read_data_burst(read_trans);
endtask

// Task: process_write
// This method continues to receive write address phase and calls
// another method to process the received transaction.
task process_write;
  forever
  begin
    axi_transaction write_trans;
```

```
      write_trans = bfm.create_slave_transaction();
      set_write_address_ready_delay(write_trans);
      bfm.get_write_addr_phase(write_trans);

      fork
        begin
          automatic axi_transaction t = write_trans;
          handle_write(t);
        end
      join_none
      #0;
    end
  endtask

  // Task: handle_write
  // This method receives write data burst or phases for a write
  // transaction based on the slave mode, write data to memory, and then
  // sends a response.
  task automatic handle_write(input axi_transaction write_trans);
    addr_t addr[];
    bit [7:0] data[];
    bit last;

    set_write_data_ready_delay(write_trans);

    if (slave_mode == AXI_TRANSACTION_SLAVE)
    begin
      bfm.get_write_data_burst(write_trans);

     for( int i = 0; bfm.get_write_addr_data(write_trans, i, addr, data);
i++ )
      begin
        for (int j = 0; j < addr.size(); j++)
          do_byte_write(addr[j], data[j]);
      end
    end
    else
    begin
      for(int i = 0; (last == 1'b0); i++)
      begin
        bfm.get_write_data_phase(write_trans, i, last);

        void'(bfm.get_write_addr_data(write_trans, i, addr, data));
        for (int j = 0; j < addr.size(); j++)
          do_byte_write(addr[j], data[j]);
      end
    end

    set_wr_resp_valid_delay(write_trans);
    bfm.execute_write_response_phase(write_trans);
  endtask

endmodule
```

# SystemVerilog AXI4 Master BFM Test Program

The following code example contains a simple AXI4 master test program that shows the master BFM API being used to communicate with a slave and create stimulus. This test program is discussed further in the SystemVerilog Tutorials Chapter.

```
//
////////////////////////////////////////////////////////////////////////////
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//
//
////////////////////////////////////////////////////////////////////////////

/*
    This is a simple example of an AXI master to demonstrate the
mgc_axi_master BFM usage.

    This master performs a directed test, initiating 4 sequential writes,
followed by 4 sequential reads. It then verifies that the data read out
matches the data written.
    For the sake of simplicity, only one data cycle is used (default AXI
burst length encoding 0).

    It then initiates two write data bursts followed by two read data
bursts.

*/

import mgc_axi_pkg::*;
module master_test_program #(int AXI_ADDRESS_WIDTH = 32, int
AXI_RDATA_WIDTH = 1024, int AXI_WDATA_WIDTH = 1024, int AXI_ID_WIDTH = 18)
(
    mgc_axi_master bfm
);

initial
begin
    axi_transaction trans;
    /******************
    ** Configuration **
    ******************/
    begin
     bfm.set_config(AXI_CONFIG_MAX_TRANSACTION_TIME_FACTOR, 1000);
    end

    /*******************
    ** Initialisation **
    *******************/
    bfm.wait_on(AXI_RESET_0_TO_1);
```

```
    bfm.wait_on(AXI_CLOCK_POSEDGE);

    /************************
    ** Traffic generation: **
    ************************/
    // 4 x Writes
    // Write data value 1 on byte lanes 1 to address 1.
    trans = bfm.create_write_transaction(1);
    trans.set_data_words(32'h0000_0100, 0);
    trans.set_write_strobes(4'b0010, 0);
    $display ( "@ %t, master_test_program: Writing data (1) to address
(1)", $time);

    // By default it will run in Blocking mode
    bfm.execute_transaction(trans);

    // Write data value 2 on byte lane 2 to address 2.
    trans = bfm.create_write_transaction(2);
    trans.set_data_words(32'h0002_0000, 0);
    trans.set_write_strobes(4'b0100, 0);
    trans.set_write_data_mode(AXI_DATA_WITH_ADDRESS);
    $display ( "@ %t, master_test_program: Writing data (2) to address
(2)", $time);

    bfm.execute_transaction(trans);

    // Write data value 3 on byte lane 3 to address 3.
    trans = bfm.create_write_transaction(3);
    trans.set_data_words(32'h0300_0000, 0);
    trans.set_write_strobes(4'b1000, 0);
    $display ( "@ %t, master_test_program: Writing data (3) to address
(3)", $time);

    bfm.execute_transaction(trans);

    // Write data value 4 to address 4 on byte lane 0.
    trans = bfm.create_write_transaction(4);
    trans.set_data_words(32'h0000_0004, 0);
    trans.set_write_strobes(4'b0001, 0);
    trans.set_write_data_mode(AXI_DATA_WITH_ADDRESS);
    $display ( "@ %t, master_test_program: Writing data (4) to address
(4)", $time);

    bfm.execute_transaction(trans);

    // 4 x Reads
    // Read data from address 1.
    trans = bfm.create_read_transaction(1);
    trans.set_size(AXI_BYTES_1);
    trans.set_id(1);

    bfm.execute_transaction(trans);
    if (trans.get_data_words(0) == 32'h0000_0100)
        $display ( "@ %t, master_test_program: Read correct data (1) at
address (1)", $time);
    else
        $display ( "@ %t master_test_program: Error: Expected data (1) at
address 1, but got %d", $time, trans.get_data_words(0));
```

```
    // Read data from address 2.
    trans = bfm.create_read_transaction(2);
    trans.set_size(AXI_BYTES_1);
    trans.set_id(2);

    bfm.execute_transaction(trans);
    if (trans.get_data_words(0) == 32'h0002_0000)
        $display ( "@ %t, master_test_program: Read correct data (2) at
address (2)", $time);
    else
       $display ( "@ %t, master_test_program: Error: Expected data (2) at
address 2, but got %d", $time, trans.get_data_words(0));

    // Read data from address 3.
    trans = bfm.create_read_transaction(3);
    trans.set_size(AXI_BYTES_1);
    trans.set_id(3);

    bfm.execute_transaction(trans);
    if (trans.get_data_words(0) == 32'h0300_0000)
      $display ( "@ %t, master_test_program: Read correct data (3) at
address (3)", $time);
    else
       $display ( "@ %t, master_test_program: Error: Expected data (3) at
address 3, but got %d", $time, trans.get_data_words(0));

    // Read data from address 4.
    trans = bfm.create_read_transaction(4);
    trans.set_size(AXI_BYTES_1);
    trans.set_id(4);

    bfm.execute_transaction(trans);
    if (trans.get_data_words(0) == 32'h0000_0004)
        $display ( "@ %t, master_test_program: Read correct data (4) at
address (4)", $time);
    else
       $display ( "@ %t, master_test_program: Error: Expected data (4) at
address 4, but got %d", $time, trans.get_data_words(0));

    // Write data burst length of 7 to start address 16.
    trans = bfm.create_write_transaction(16, 7);

    trans.set_data_words(`hACE0ACE1, 0);
    trans.set_data_words(`hACE2ACE3, 1);
    trans.set_data_words(`hACE4ACE5, 2);
    trans.set_data_words(`hACE6ACE7, 3);
    trans.set_data_words(`hACE8ACE9, 4);
    trans.set_data_words(`hACEAACEB, 5);
    trans.set_data_words(`hACECACED, 6);
    trans.set_data_words(`hACEEACEF, 7);
    for(int i=0; i<8; i++)
        trans.set_write_strobes(4'b1111, i);

    trans.set_write_data_mode(AXI_DATA_WITH_ADDRESS);
    $display ( "@ %t, master_test_program: Writing data burst of length 7
to start address 16", $time);
```

```
    bfm.execute_transaction(trans);

    // Write data burst of length 7 to start address 128 with LSB write
strobe inactive.
    trans = bfm.create_write_transaction(128, 7);

    trans.set_data_words(‘hACE0ACE1, 0);
    trans.set_data_words(‘hACE2ACE3, 1);
    trans.set_data_words(‘hACE4ACE5, 2);
    trans.set_data_words(‘hACE6ACE7, 3);
    trans.set_data_words(‘hACE8ACE9, 4);
    trans.set_data_words(‘hACEAACEB, 5);
    trans.set_data_words(‘hACECACED, 6);
    trans.set_data_words(‘hACEEACEF, 7);

    trans.set_write_strobes(4’b1110, 0);
    for(int i=1; i<8; i++)
        trans.set_write_strobes(4’b1111, i);
    $display ( “@ %t, master_test_program: Writing data burst of length 7
to start address 128”, $time);

    bfm.execute_transaction(trans);

    // Read data burst of length 1 from address 16.
    trans = bfm.create_read_transaction(16, 1);

    bfm.execute_transaction(trans);
    if (trans.get_data_words(0) == ‘hACE0ACE1)
      $display ( “@ %t, master_test_program: Read correct data (hACE0ACE1)
at address (16)”, $time);
    else
      $display ( “@ %t, master_test_program: Error: Expected data
(hACE0ACE1) at address (16), but got %h”, $time, trans.get_data_words(0));

    if (trans.get_data_words(1) == ‘hACE2ACE3)
      $display ( “@ %t, master_test_program: Read correct data (hACE2ACE3)
at address (20)”, $time);
    else
      $display ( “@ %t, master_test_program: Error: Expected data
(hACE2ACE3) at address (20), but got %h”, $time, trans.get_data_words(1));


    // Read data burst of length 1 from address 128.
    trans = bfm.create_read_transaction(128, 1);

    bfm.execute_transaction(trans);
    if (trans.get_data_words(0) == ‘hACE0AC00)
      $display ( “@ %t, master_test_program: Read correct data (hACE0AC00)
at address (128)”, $time);
    else
      $display ( “@ %t, master_test_program: Error: Expected data
(hACE0AC00) at address (128), but got %h”, $time,
trans.get_data_words(0));

    if (trans.get_data_words(1) == ‘hACE2ACE3)
      $display ( “@ %t, master_test_program: Read correct data (hACE2ACE3)
at address (132)”, $time);
    else
```

```
      $display ( "@ %t, master_test_program: Error: Expected data
(hACE2ACE3) at address (132), but got %h", $time,
trans.get_data_words(1));

    #100
    $finish();
end
endmodule
```

# SystemVerilog AXI4 Slave BFM Test Program

The following code example contains a simple AXI4 slave test program that shows the slave BFM API being used to communicate with a master and create stimulus. This test program is discussed further in the SystemVerilog Tutorials Chapter.

```
//
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//
//
////////////////////////////////////////////////////////////////////////////

/*
    This is a simple example of an AXI Slave to demonstrate the
mgc_axi_slave BFM usage.

   This is a fairly generic slave which handles almost all write and read
transaction
    scenarios from master. It handles write data with address as well as
data after address
    both.

    This slave code is divided in two parts, one which user might need to
edit to change slave
    mode (Transaction/burst or Phase level) and memory handling.
   Out of the code which is grouped as user do not need to edit, could be
edited for achieving
    required phase valid/ready delays.
*/


import mgc_axi_pkg::*;

module slave_test_program #(int AXI_ADDRESS_WIDTH = 32, int
AXI_RDATA_WIDTH = 32, int AXI_WDATA_WIDTH = 32, int AXI_ID_WIDTH = 18)
(
    mgc_axi_slave bfm
);
```

```
  typedef bit [((AXI_ADDRESS_WIDTH) - 1) : 0] addr_t;

  // Enum type for slave mode
  // AXI_TRANSACTION_SLAVE - Works at burst level (write data is received
at
  //                         burst and read data/response is sent in burst)
  // AXI_PHASE_SLAVE       - Write data and read data/response is worked
upon
  //                          at phase level
  typedef enum bit
  {
    AXI_TRANSACTION_SLAVE = 1'b0,
    AXI_PHASE_SLAVE       = 1'b1
  } axi_slave_mode_e;

  ////////////////////////////////////////////////
  // Code user could edit according to requirements
  ////////////////////////////////////////////////

  // Slave mode seclection : default it is transaction level slave
  axi_slave_mode_e slave_mode = AXI_TRANSACTION_SLAVE;

  // Storage for a memory
  bit [7:0] mem [*];

  // Function : do_byte_read
  // Function to provide read data byte from memory at particular input
  // address
  function bit[7:0] do_byte_read(addr_t addr);
    return mem[addr];
  endfunction

  // Function : do_byte_write
  // Function to write data byte to memory at particular input address
  function void do_byte_write(addr_t addr, bit [7:0] data);
    mem[addr] = data;
  endfunction

  // Function : set_write_address_ready_delay
  // This is used to set write address phase ready delay to extend phase
  function void set_write_address_ready_delay(axi_transaction trans);
    trans.set_address_ready_delay(2);
  endfunction

  // Function : set_read_address_ready_delay
  // This is used to set read address phase ready delay to entend phase
  function void set_read_address_ready_delay(axi_transaction trans);
    trans.set_address_ready_delay(4);
  endfunction

  // Function : set_write_data_ready_delay
  // This will set the ready delays for each write data phase in a write
data
  // burst
  function void set_write_data_ready_delay(axi_transaction trans);
    for (int i = 0; i < trans.data_ready_delay.size(); i++)
      trans.set_data_ready_delay(i, i);
```

```
  endfunction

  // Function : set_wr_resp_valid_delay
  // This is used to set write response phase valid delay to start driving
  // write response phase after specified delay.
  function void set_wr_resp_valid_delay(axi_transaction trans);
    trans.set_write_response_valid_delay(2);
  endfunction

  // Function : set_read_data_valid_delay
  // This is used to set read response phase valid delays to start driving
  // read data/response phases after specified delay.
  function void set_read_data_valid_delay(axi_transaction trans);
    for (int i = 0; i < trans.data_valid_delay.size(); i++)
      trans.set_data_valid_delay(i, i);
  endfunction


  ////////////////////////////////////////////////////////////////////////
  // Code user do not need to edit
  // Please note that in this part of code base below delays are assigned
  // which user might need to change according to requirement
  // address_ready_delay : This is for write and read address phase both
  // data_valid_delay    : This is for sending read data/response valid
  // data_ready_delay    : This is for write data phase ready delay
  ////////////////////////////////////////////////////////////////////////
  initial
  begin
    // Initialisation
    bfm.wait_on(AXI_RESET_0_TO_1);
    bfm.wait_on(AXI_CLOCK_POSEDGE);

    // Traffic generation
    fork
      process_read;
      process_write;
    join
  end

  // Task : process_read
  // This method keep receiving read address phase and calls another
method to
  // process received transaction.
  task process_read;
    forever
    begin
      axi_transaction read_trans;

      read_trans = bfm.create_slave_transaction();
      set_read_address_ready_delay(read_trans);
      bfm.get_read_addr_phase(read_trans);

      fork
        begin
          automatic axi_transaction t = read_trans;
          handle_read(t);
        end
      join_none
```

```
      #0;
    end
  endtask

  // Task : handle_read
  // This method reads data from memory and send read data/response either
at
  // burst or phase level depending upon slave working mode.
  task automatic handle_read(input axi_transaction read_trans);
    addr_t addr[];
    bit [7:0] mem_data[];

    set_read_data_valid_delay(read_trans);

    for(int i = 0; bfm.get_read_addr(read_trans, i, addr); i++)
    begin
      mem_data = new[addr.size()];
      for (int j = 0; j < addr.size(); j++)
        mem_data[j] = do_byte_read(addr[j]);

      bfm.set_read_data(read_trans, i, addr, mem_data);

      if (slave_mode == AXI_PHASE_SLAVE)
        bfm.execute_read_data_phase(read_trans, i);
    end

    if (slave_mode == AXI_TRANSACTION_SLAVE)
      bfm.execute_read_data_burst(read_trans);
  endtask

  // Task : process_write
  // This method keep receiving write address phase and calls another
method to
  // process received transaction.
  task process_write;
    forever
    begin
      axi_transaction write_trans;

      write_trans = bfm.create_slave_transaction();
      set_write_address_ready_delay(write_trans);
      bfm.get_write_addr_phase(write_trans);

      fork
        begin
          automatic axi_transaction t = write_trans;
          handle_write(t);
        end
      join_none
      #0;
    end
  endtask

  // Task : handle_write
  // This method receive write data burst or phases for write transaction
  // depending upon slave working mode, write data to memory and then send
  // response
  task automatic handle_write(input axi_transaction write_trans);
```

```
    addr_t addr[];
    bit [7:0] data[];
    bit last;

    set_write_data_ready_delay(write_trans);

    if (slave_mode == AXI_TRANSACTION_SLAVE)
    begin
      bfm.get_write_data_burst(write_trans);

     for( int i = 0; bfm.get_write_addr_data(write_trans, i, addr, data);
i++ )
      begin
        for (int j = 0; j < addr.size(); j++)
          do_byte_write(addr[j], data[j]);
      end
    end
    else
    begin
      for(int i = 0; (last == 1'b0); i++)
      begin
        bfm.get_write_data_phase(write_trans, i, last);

        void'(bfm.get_write_addr_data(write_trans, i, addr, data));
        for (int j = 0; j < addr.size(); j++)
          do_byte_write(addr[j], data[j]);
      end
    end

    set_wr_resp_valid_delay(write_trans);
    bfm.execute_write_response_phase(write_trans);
  endtask

endmodule
```

# Appendix C
# VHDL AXI3 and AXI4 Test Programs

This appendix contains AXI3 and AXI4 VHDL test programs, one for the Master BFM and the other for the Slave BFM for each protocol.

## VHDL AXI3 Master BFM Test Program

The following code example contains a simple AXI3 master test program that shows the master BFM API being used to communicate with a slave and create stimulus. This test program is discussed further in the VHDL Tutorials Chapter.

```
******************************************************************************
--
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--
******************************************************************************

-- This simplified example of an AXI master shows you how to use the
-- mgc_axi_master BFM.
--
-- This master performs a directed test, initiating 4 sequential writes,
-- followed by 4 sequential reads. It then verifies that the data read out
-- matches the data written. To retain simplicity, only one data cycle is
-- used (default AXI burst length encoding 0). It then initiates two write
-- data bursts, followed by two read data bursts.

library ieee;
use ieee.std_logic_1164.all;

library work;
use work.all;
use work.mgc_axi_bfm_pkg.all;

entity master_test_program is
 generic (AXI_ADDRESS_WIDTH : integer := 32;
          AXI_RDATA_WIDTH : integer := 1024;
          AXI_WDATA_WIDTH : integer := 1024;
          AXI_ID_WIDTH : integer := 4;
          index : integer range 0 to 511 :=0
         );
end master_test_program;
```

```
architecture master_test_program_a of master_test_program is
begin

  -- Master test
  process
    variable tr_id: integer;
    variable data_words         :  std_logic_vector(AXI_MAX_BIT_SIZE-1
downto 0);
  begin
    wait_on(AXI_RESET_0_TO_1, index, axi_tr_if_0(index));
    wait_on(AXI_CLOCK_POSEDGE, index, axi_tr_if_0(index));

    -- 4 x Writes
    -- Write data value 1 on byte lanes 1 to address 1.
    create_write_transaction(1, tr_id, index, axi_tr_if_0(index));
    data_words(31 downto 0) := x"00000100";
    set_data_words(data_words, tr_id, index, axi_tr_if_0(index));
    set_write_strobes(2, tr_id, index, axi_tr_if_0(index));
    report "master_test_program: Writing data (1) to address (1)";

    -- By default it will run in Blocking mode
    execute_transaction(tr_id, index, axi_tr_if_0(index));

    -- Write data value 2 on byte lane 2 to address 2.
    create_write_transaction(2, tr_id, index, axi_tr_if_0(index));
    data_words(31 downto 0) := x"00020000";
    set_data_words(data_words, tr_id, index, axi_tr_if_0(index));
    set_write_strobes(4, tr_id, index, axi_tr_if_0(index));
    report "master_test_program: Writing data (2) to address (2)";

    -- By default it will run in Blocking mode
    execute_transaction(tr_id, index, axi_tr_if_0(index));

    -- Write data value 3 on byte lane 3 to address 3.
    create_write_transaction(3, tr_id, index, axi_tr_if_0(index));
    data_words(31 downto 0) := x"03000000";
    set_data_words(data_words, tr_id, index, axi_tr_if_0(index));
    set_write_strobes(8, tr_id, index, axi_tr_if_0(index));
    report "master_test_program: Writing data (3) to address (3)";

    -- By default it will run in Blocking mode
    execute_transaction(tr_id, index, axi_tr_if_0(index));

    -- Write data value 4 on byte lane 0 to address 4.
    create_write_transaction(4, tr_id, index, axi_tr_if_0(index));
    data_words(31 downto 0) := x"00000004";
    set_data_words(data_words, tr_id, index, axi_tr_if_0(index));
    set_write_strobes(1, tr_id, index, axi_tr_if_0(index));
    report "master_test_program: Writing data (4) to address (4)";

    -- By default it will run in Blocking mode
    execute_transaction(tr_id, index, axi_tr_if_0(index));
```

```
    --4 x Reads
    --Read data from address 1.
    create_read_transaction(1, tr_id, index, axi_tr_if_0(index));
    set_id(1, tr_id, index, axi_tr_if_0(index));
    execute_transaction(tr_id, index, axi_tr_if_0(index));

    get_data_words(data_words, tr_id, index, axi_tr_if_0(index));
    if(data_words(31 downto 0) = x"00000100") then
      report "master_test_program: Read correct data (1) at address (1)";
    else
     report "master_test_program: Expected data (1) at address 1, but got
" & integer'image(to_integer(data_words(31 downto 0)));
    end if;

    --Read data from address 2.
    create_read_transaction(2, tr_id, index, axi_tr_if_0(index));
    set_id(2, tr_id, index, axi_tr_if_0(index));
    execute_transaction(tr_id, index, axi_tr_if_0(index));

    get_data_words(data_words, tr_id, index, axi_tr_if_0(index));
    if(data_words(31 downto 0) = x"00020000") then
      report "master_test_program: Read correct data (2) at address (2)";
    else
     report "master_test_program: Expected data (2) at address 2, but got
" & integer'image(to_integer(data_words(31 downto 0)));
    end if;

    --Read data from address 3.
    create_read_transaction(3, tr_id, index, axi_tr_if_0(index));
    set_id(3, tr_id, index, axi_tr_if_0(index));
    execute_transaction(tr_id, index, axi_tr_if_0(index));

    get_data_words(data_words, tr_id, index, axi_tr_if_0(index));
    if(data_words(31 downto 0) = x"03000000") then
      report "master_test_program: Read correct data (3) at address (3)";
    else
     report "master_test_program: Expected data (3) at address 3, but got
" & integer'image(to_integer(data_words(31 downto 0)));
    end if;

    --Read data from address 4.
    create_read_transaction(4, tr_id, index, axi_tr_if_0(index));
    set_id(4, tr_id, index, axi_tr_if_0(index));
    execute_transaction(tr_id, index, axi_tr_if_0(index));

    get_data_words(data_words, tr_id, index, axi_tr_if_0(index));
    if(data_words(31 downto 0) = x"00000004") then
      report "master_test_program: Read correct data (4) at address (4)";
    else
     report "master_test_program: Expected data (4) at address 4, but got
" & integer'image(to_integer(data_words(31 downto 0)));
    end if;
```

```
-- Write data burst length of 7 to start address 16.
create_write_transaction(16, 7, tr_id, index, axi_tr_if_0(index));
set_size(AXI_BYTES_4, tr_id, index, axi_tr_if_0(index));
data_words(31 downto 0) := x"ACE0ACE1";
set_data_words(data_words, 0, tr_id, index, axi_tr_if_0(index));
data_words(31 downto 0) := x"ACE2ACE3";
set_data_words(data_words, 1, tr_id, index, axi_tr_if_0(index));
data_words(31 downto 0) := x"ACE4ACE5";
set_data_words(data_words, 2, tr_id, index, axi_tr_if_0(index));
data_words(31 downto 0) := x"ACE6ACE7";
set_data_words(data_words, 3, tr_id, index, axi_tr_if_0(index));
data_words(31 downto 0) := x"ACE8ACE9";
set_data_words(data_words, 4, tr_id, index, axi_tr_if_0(index));
data_words(31 downto 0) := x"ACEAACEB";
set_data_words(data_words, 5, tr_id, index, axi_tr_if_0(index));
data_words(31 downto 0) := x"ACECACED";
set_data_words(data_words, 6, tr_id, index, axi_tr_if_0(index));
data_words(31 downto 0) := x"ACEEACEF";
set_data_words(data_words, 7, tr_id, index, axi_tr_if_0(index));
for i in  0 to 7 loop
  set_write_strobes(15, i, tr_id, index, axi_tr_if_0(index));
end loop;
set_write_data_mode(AXI_DATA_WITH_ADDRESS, tr_id, index,
axi_tr_if_0(index));
execute_transaction(tr_id, index, axi_tr_if_0(index));

-- Write data burst length of 7 to start address 128 with
-- LSB write strobe inactive.
create_write_transaction(128, 7, tr_id, index, axi_tr_if_0(index));
set_size(AXI_BYTES_4, tr_id, index, axi_tr_if_0(index));
data_words(31 downto 0) := x"ACE0ACE1";
set_data_words(data_words, 0, tr_id, index, axi_tr_if_0(index));
data_words(31 downto 0) := x"ACE2ACE3";
set_data_words(data_words, 1, tr_id, index, axi_tr_if_0(index));
data_words(31 downto 0) := x"ACE4ACE5";
set_data_words(data_words, 2, tr_id, index, axi_tr_if_0(index));
data_words(31 downto 0) := x"ACE6ACE7";
set_data_words(data_words, 3, tr_id, index, axi_tr_if_0(index));
data_words(31 downto 0) := x"ACE8ACE9";
set_data_words(data_words, 4, tr_id, index, axi_tr_if_0(index));
data_words(31 downto 0) := x"ACEAACEB";
set_data_words(data_words, 5, tr_id, index, axi_tr_if_0(index));
data_words(31 downto 0) := x"ACECACED";
set_data_words(data_words, 6, tr_id, index, axi_tr_if_0(index));
data_words(31 downto 0) := x"ACEEACEF";
set_data_words(data_words, 7, tr_id, index, axi_tr_if_0(index));
set_write_strobes(14, 0, tr_id, index, axi_tr_if_0(index));
for i in  1 to 7 loop
  set_write_strobes(15, i, tr_id, index, axi_tr_if_0(index));
end loop;
execute_transaction(tr_id, index, axi_tr_if_0(index));

-- Read data burst of length 1 from address 16.
create_read_transaction(16, 1, tr_id, index, axi_tr_if_0(index));
set_size(AXI_BYTES_4, tr_id, index, axi_tr_if_0(index));
execute_transaction(tr_id, index, axi_tr_if_0(index));
```

```
    get_data_words(data_words, 0, tr_id, index, axi_tr_if_0(index));
    if(data_words(31 downto 0) = x"ACE0ACE1") then
      report "master_test_program: Read correct data (hACE0ACE1) at
address (16)";
    else
     report "master_test_program: Expected data (hACE0ACE1) at address
(16), but got " & integer'image(to_integer(data_words(31 downto 0)));
    end if;
    get_data_words(data_words, 1, tr_id, index, axi_tr_if_0(index));
    if(data_words(31 downto 0) = x"ACE2ACE3") then
      report "master_test_program: Read correct data (hACE2ACE3) at
address (20)";
    else
     report "master_test_program: Expected data (hACE2ACE3) at address
(20), but got " & integer'image(to_integer(data_words(31 downto 0)));
    end if;

    -- Read data burst of length 1 from address 128.
    create_read_transaction(128, 1, tr_id, index, axi_tr_if_0(index));
    set_size(AXI_BYTES_4, tr_id, index, axi_tr_if_0(index));
    execute_transaction(tr_id, index, axi_tr_if_0(index));

    get_data_words(data_words, 0, tr_id, index, axi_tr_if_0(index));
    if(data_words(31 downto 0) = x"ACE0AC00") then
     report "master_test_program: Read correct data (ACE0AC00) at address
(128)";
    else
     report "master_test_program: Expected data (ACE0AC00) at address
(128), but got " & integer'image(to_integer(data_words(31 downto 0)));
    end if;
    get_data_words(data_words, 1, tr_id, index, axi_tr_if_0(index));
    if(data_words(31 downto 0) = x"ACE2ACE3") then
      report "master_test_program: Read correct data (hACE2ACE3) at
address (132)";
    else
     report "master_test_program: Expected data (hACE2ACE3) at address
(132), but got " & integer'image(to_integer(data_words(31 downto 0)));
    end if;

    wait for 100 ns;
    assert false report "NONE: End of Simulation." severity failure;
  end process;
end master_test_program_a;
```

# VHDL AXI3 Slave BFM Test Program

The following code example contains a simple AXI3 slave test program that shows the slave BFM API being used to communicate with a master and create stimulus. This test program is discussed further in the VHDL Tutorials Chapter.

```
**************************************************************************
--
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-- TO LICENSE TERMS.
--
**************************************************************************
--
-- This simplfied example of an AXI Slave demonstrates using the
-- mgc_axi_slave BFM. This fairly generic slave handles almost all write
-- and read transaction scenarios from the master. It handles both, write
-- data with address, as well as data after the address.
--
-- This slave code is divided in two parts, one which the user might need
-- to edit to change the slave mode(for example, for Transaction/burst or
-- Phase level) and memory handling.
-- Other code, which is labeled, "user need not edit", can be edited if
-- user needs to meet required phase valid/ready delays.
--
library ieee ;
use ieee.std_logic_1164.all;
use ieee.std_logic_arith.all;

library work;
use work.all;
use work.mgc_axi_bfm_pkg.all;

entity slave_test_program is
   generic (AXI_ADDRESS_WIDTH : integer := 32;
            AXI_RDATA_WIDTH : integer := 1024;
            AXI_WDATA_WIDTH : integer := 1024;
            AXI_ID_WIDTH : integer := 4;
            index : integer range 0 to 511 := 0
            );
 end slave_test_program;

architecture slave_test_program_a of slave_test_program is
  type axi_slave_mode_e is (AXI_TRANSACTION_SLAVE, AXI_PHASE_SLAVE);
  type memory_t is array (0 to 2**16-1) of std_logic_vector(7 downto 0);
  shared variable mem : memory_t;
```

```
  signal slave_mode : axi_slave_mode_e := AXI_TRANSACTION_SLAVE;
  procedure do_byte_read(addr : in std_logic_vector(AXI_MAX_BIT_SIZE-1
downto 0); data : out std_logic_vector(7 downto 0));
  procedure do_byte_write(addr : in std_logic_vector(AXI_MAX_BIT_SIZE-1
downto 0);  data : in std_logic_vector(7 downto 0));
  procedure set_write_address_ready_delay(id : integer; signal tr_if :
inout axi_vhd_if_struct_t);
  procedure set_write_address_ready_delay(id : integer; path_id : in
axi_path_t; signal tr_if : inout axi_vhd_if_struct_t);
  procedure set_read_address_ready_delay(id : integer; signal tr_if :
inout axi_vhd_if_struct_t);
  procedure set_read_address_ready_delay(id : integer; path_id : in
axi_path_t; signal tr_if : inout axi_vhd_if_struct_t);
  procedure set_write_data_ready_delay(id : integer; signal tr_if : inout
axi_vhd_if_struct_t);
  procedure set_write_data_ready_delay(id : integer; path_id : in
axi_path_t; signal tr_if : inout axi_vhd_if_struct_t);
  procedure set_wr_resp_valid_delay(id : integer; signal tr_if : inout
axi_vhd_if_struct_t);
 procedure set_wr_resp_valid_delay(id : integer; path_id : in axi_path_t;
signal tr_if : inout axi_vhd_if_struct_t);
  procedure set_read_data_valid_delay(id : integer; signal tr_if : inout
axi_vhd_if_struct_t);
  procedure set_read_data_valid_delay(id : integer; path_id : in
axi_path_t; signal tr_if : inout axi_vhd_if_struct_t);

  -- Procedure: do_byte_read
  -- This procedure specifies the read data byte wil be read from memory at
  -- a particular input address.
  procedure do_byte_read(addr : in std_logic_vector(AXI_MAX_BIT_SIZE-1
downto 0); data: out std_logic_vector(7 downto 0)) is
  begin
    data := mem(to_integer(addr));
  end do_byte_read;

  -- Procedure: do_byte_write
  -- This procedure writes a data byte to memory at a particular input
  -- address.
  procedure do_byte_write(addr : in std_logic_vector(AXI_MAX_BIT_SIZE-1
downto 0);  data : in std_logic_vector(7 downto 0)) is
  begin
    mem(to_integer(addr)) := data;
  end do_byte_write;

  -- Procedure: set_write_address_ready_delay
  -- This procedure sets and extends the write address phase ready delay
  -- phase.
  procedure set_write_address_ready_delay(id : integer; signal tr_if :
inout axi_vhd_if_struct_t) is
  begin
    set_address_ready_delay(2, id, index, tr_if);
  end set_write_address_ready_delay;
  procedure set_write_address_ready_delay(id : integer; path_id : in
axi_path_t; signal tr_if : inout axi_vhd_if_struct_t) is
  begin
    set_address_ready_delay(2, id, index, path_id, tr_if);
  end set_write_address_ready_delay;
```

```
  -- Procedure: set_read_address_ready_delay
  -- This procedure sets and extends the read address phase ready delay.
  procedure set_read_address_ready_delay(id : integer; signal tr_if :
inout axi_vhd_if_struct_t) is
  begin
    set_address_ready_delay(4, id, index, tr_if);
  end set_read_address_ready_delay;
  procedure set_read_address_ready_delay(id : integer; path_id : in
axi_path_t; signal tr_if : inout axi_vhd_if_struct_t) is
  begin
    set_address_ready_delay(4, id, index, path_id, tr_if);
  end set_read_address_ready_delay;

  -- Procedure: set_write_data_ready_delay
  -- This procedure sets the ready delays for each write data phase in a
  --write data burst.
  procedure set_write_data_ready_delay(id : integer; signal tr_if : inout
axi_vhd_if_struct_t) is
    variable burst_length : integer;
  begin
    get_burst_length(burst_length, id, index, tr_if);
    for i in  0 to burst_length loop
      set_data_ready_delay(i, i, id, index, tr_if);
    end loop;
  end set_write_data_ready_delay;
  procedure set_write_data_ready_delay(id : integer; path_id : in
axi_path_t; signal tr_if : inout axi_vhd_if_struct_t) is
    variable burst_length : integer;
  begin
    get_burst_length(burst_length, id, index, path_id, tr_if);
    for i in  0 to burst_length loop
      set_data_ready_delay(i, i, id, index, path_id, tr_if);
    end loop;
  end set_write_data_ready_delay;

  -- Procedure: set_wr_resp_valid_delay
  -- This procedure sets the write response phase valid delay to start
  -- driving write response phase after the specified delay.
  procedure set_wr_resp_valid_delay(id : integer; signal tr_if : inout
axi_vhd_if_struct_t) is
  begin
    set_write_response_valid_delay(0, id, index, tr_if);
  end set_wr_resp_valid_delay;
 procedure set_wr_resp_valid_delay(id : integer; path_id : in axi_path_t;
signal tr_if : inout axi_vhd_if_struct_t) is
  begin
    set_write_response_valid_delay(0, id, index, path_id, tr_if);
  end set_wr_resp_valid_delay;
```

```
  -- Procedure: set_read_data_valid_delay
  -- This procedure sets the ready delays for each write data phase in a
  --write data burst.
  procedure set_read_data_valid_delay(id : integer; signal tr_if : inout
axi_vhd_if_struct_t) is
    variable burst_length : integer;
  begin
    get_burst_length(burst_length, id, index, tr_if);
    for i in  0 to burst_length loop
      set_data_valid_delay(i, i, id, index, tr_if);
    end loop;
  end set_read_data_valid_delay;
  procedure set_read_data_valid_delay(id : integer; path_id : in
axi_path_t; signal tr_if : inout axi_vhd_if_struct_t) is
    variable burst_length : integer;
  begin
    get_burst_length(burst_length, id, index, path_id, tr_if);
    for i in  0 to burst_length loop
      set_data_valid_delay(i, i, id, index, path_id, tr_if);
    end loop;
  end set_read_data_valid_delay;

begin

  -- To create pipelining in VHDL there are multiple channel paths in each
  -- API. Each process chooses a separate path to interact with the BFM.
  -- process_write: write address phase through path 0
  -- This process continuously receives write address phase and pushes
  -- the transaction into the queue through the push_transaction_id API.
  process
    variable write_trans : integer;
  begin
    wait for 1ns;
    wait_on(AXI_RESET_0_TO_1, index, axi_tr_if_0(index));
    loop
      create_slave_transaction(write_trans, index, axi_tr_if_0(index));
      set_write_address_ready_delay(write_trans, axi_tr_if_0(index));
      get_write_addr_phase(write_trans, index, axi_tr_if_0(index));
      push_transaction_id(write_trans, AXI_QUEUE_ID_0, index,
axi_tr_if_0(index));
    end loop;
    wait;
  end process;
```

```
  -- handle_write: writes data phase through path 1
  -- This method receives the write data burst or phases for write
  -- transactions based on the slave working mode and the write data to
  -- memory.
  process
    variable write_trans: integer;
    variable byte_length : integer;
    variable burst_length : integer;
    variable addr : std_logic_vector(AXI_MAX_BIT_SIZE-1 downto 0);
    variable data : std_logic_vector(7 downto 0);
    variable last : integer := 0;
    variable loop_i : integer := 0;
  begin
    loop
      pop_transaction_id(write_trans, AXI_QUEUE_ID_0, index, AXI_PATH_1,
axi_tr_if_1(index));
      set_write_data_ready_delay(write_trans, AXI_PATH_1,
axi_tr_if_1(index));

      if (slave_mode = AXI_TRANSACTION_SLAVE) then
        get_write_data_burst(write_trans, index, AXI_PATH_1,
axi_tr_if_1(index));
        get_burst_length(burst_length, write_trans, index, AXI_PATH_1,
axi_tr_if_1(index));
        for i in  0 to burst_length loop
         get_write_addr_data(write_trans,  i, 0, byte_length, addr, data,
index, AXI_PATH_1, axi_tr_if_1(index));
          do_byte_write(addr, data);
          if byte_length > 1 then
            for j in 1 to byte_length-1 loop
               get_write_addr_data(write_trans,  i, j, byte_length, addr,
data, index, AXI_PATH_1, axi_tr_if_1(index));
               do_byte_write(addr, data);
            end loop;
          end if;
        end loop;
      else
        last := 0;
        loop_i := 0;
        while(last = 0) loop
          get_write_data_phase(write_trans, loop_i, last, index,
AXI_PATH_1, axi_tr_if_1(index));
          loop_i := loop_i + 1;
          get_write_addr_data(write_trans,  loop_i, 0, byte_length, addr,
data, index, AXI_PATH_1, axi_tr_if_1(index));
          do_byte_write(addr, data);
          if byte_length > 1 then
            for j in 1 to byte_length-1 loop
               get_write_addr_data(write_trans,  loop_i, j, byte_length,
addr, data, index, AXI_PATH_1, axi_tr_if_1(index));
               do_byte_write(addr, data);
            end loop;
          end if;
        end loop;
      end if;
      push_transaction_id(write_trans, AXI_QUEUE_ID_2, index, AXI_PATH_1,
axi_tr_if_1(index));
    end loop;
```

```
    wait;
  end process;

  -- handle_response: writes response phase through path 2
  -- This method sends the write response phase
  process
    variable write_trans: integer;
  begin
    loop
      pop_transaction_id(write_trans, AXI_QUEUE_ID_2, index, AXI_PATH_2,
axi_tr_if_2(index));
      set_wr_resp_valid_delay(write_trans, AXI_PATH_2,
axi_tr_if_2(index));
      execute_write_response_phase(write_trans, index, AXI_PATH_2,
axi_tr_if_2(index));
    end loop;
    wait;
  end process;

  -- process_read: reads the address phase through path 3
  -- This process contiuooously receives the read address phase and pushes
  -- the transaction into queue through the push_transaction_id API.
  process
    variable read_trans: integer;
  begin
    wait for 1ns;
    wait_on(AXI_RESET_0_TO_1, index, AXI_PATH_3, axi_tr_if_3(index));
    loop
      create_slave_transaction(read_trans, index, AXI_PATH_3,
axi_tr_if_3(index));
      set_read_address_ready_delay(read_trans, AXI_PATH_3,
axi_tr_if_3(index));
      get_read_addr_phase(read_trans, index, AXI_PATH_3,
axi_tr_if_3(index));
      push_transaction_id(read_trans, AXI_QUEUE_ID_1, index, AXI_PATH_3,
axi_tr_if_3(index));
    end loop;
    wait;
  end process;

  -- handle_read: reads the data and responds through path 4
  -- This process reads data from memory and sends the read data/response
  -- either at the burst or phase level, based on the slave mode.
  process
    variable read_trans: integer;
    variable burst_length : integer;
    variable byte_length : integer;
    variable addr : std_logic_vector(AXI_MAX_BIT_SIZE-1 downto 0);
    variable data : std_logic_vector(7 downto 0);
  begin
    loop
      pop_transaction_id(read_trans, AXI_QUEUE_ID_1, index, AXI_PATH_4,
axi_tr_if_4(index));
      set_read_data_valid_delay(read_trans, AXI_PATH_4,
axi_tr_if_4(index));
```

```
      get_burst_length(burst_length, read_trans, index, AXI_PATH_4,
axi_tr_if_4(index));
      for i in  0 to burst_length loop
        get_read_addr(read_trans,  i, 0, byte_length, addr, index,
AXI_PATH_4, axi_tr_if_4(index));
        do_byte_read(addr, data);
        set_read_data(read_trans, i, 0, byte_length, addr, data, index,
AXI_PATH_4, axi_tr_if_4(index));
        if slave_mode = AXI_PHASE_SLAVE then
          execute_read_data_phase(read_trans, i, index, AXI_PATH_4,
axi_tr_if_4(index));
        end if;
        if byte_length > 1 then
          for j in 1 to byte_length-1 loop
             get_read_addr(read_trans,  i, j, byte_length, addr, index,
AXI_PATH_4, axi_tr_if_4(index));
             do_byte_read(addr, data);
             set_read_data(read_trans, i, j, byte_length, addr, data,
index, AXI_PATH_4, axi_tr_if_4(index));
             if slave_mode = AXI_PHASE_SLAVE then
               execute_read_data_phase(read_trans, i, index, AXI_PATH_4,
axi_tr_if_4(index));
             end if;
          end loop;
        end if;
      end loop;
      if slave_mode = AXI_TRANSACTION_SLAVE then
        execute_read_data_burst(read_trans, index, AXI_PATH_4,
axi_tr_if_4(index));
      end if;
    end loop;
    wait;
  end process;
end slave_test_program_a;
```

# VHDL AXI4 Master BFM Test Program

The following code example contains a simple AXI4 master test program that shows the master BFM API being used to communicate with a slave and to create stimulus. This test program is discussed further in the VHDL Tutorials Chapter.

```
-- ****************************************************************************
--
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TERMS.
--
-- ****************************************************************************
```

```
--    This is a simple example of an AXI master to demonstrate the
mgc_axi_master BFM usage.
--
--    This master performs a directed test, initiating 4 sequential
writes, followed by 4 sequential reads.
--    It then verifies that the data read out matches the data written.
--    For the sake of simplicity, only one data cycle is used (default AXI
burst length encoding 0).
--
--    It then initiates two write data bursts followed by two read data
bursts.

library ieee ;
use ieee.std_logic_1164.all;

library work;
use work.all;
use work.mgc_axi_bfm_pkg.all;
use std.textio.all;
use ieee.std_logic_textio.all;

entity master_test_program is
 generic (AXI_ADDRESS_WIDTH : integer := 32;
          AXI_RDATA_WIDTH : integer := 1024;
          AXI_WDATA_WIDTH : integer := 1024;
          AXI_ID_WIDTH : integer := 18;
          index : integer range 0 to 511 :=0
         );
end master_test_program;

architecture master_test_program_a of master_test_program is
begin

  -- Master test
  process
    variable tr_id: integer;
    variable data_words         :  std_logic_vector(AXI_MAX_BIT_SIZE-1
downto 0);
    variable lp: line;
  begin
    wait_on(AXI_RESET_0_TO_1, index, axi_tr_if_0(index));
    wait_on(AXI_CLOCK_POSEDGE, index, axi_tr_if_0(index));

    -- 4 x Writes
    -- Write data value 1 on byte lanes 1 to address 1.
    create_write_transaction(1, tr_id, index, axi_tr_if_0(index));
    data_words(31 downto 0) := x"00000100";
    set_data_words(data_words, tr_id, index, axi_tr_if_0(index));
    set_write_strobes(2, tr_id, index, axi_tr_if_0(index));
    report "master_test_program: Writing data (1) to address (1)";

    -- By default it will run in Blocking mode
    execute_transaction(tr_id, index, axi_tr_if_0(index));


    -- Write data value 2 on byte lane 2 to address 2.
    create_write_transaction(2, tr_id, index, axi_tr_if_0(index));
    data_words(31 downto 0) := x"00020000";
```

```
    set_data_words(data_words, tr_id, index, axi_tr_if_0(index));
    set_write_strobes(4, tr_id, index, axi_tr_if_0(index));
    report "master_test_program: Writing data (2) to address (2)";

    -- By default it will run in Blocking mode
    execute_transaction(tr_id, index, axi_tr_if_0(index));

    -- Write data value 3 on byte lane 3 to address 3.
    create_write_transaction(3, tr_id, index, axi_tr_if_0(index));
    data_words(31 downto 0) := x"03000000";
    set_data_words(data_words, tr_id, index, axi_tr_if_0(index));
    set_write_strobes(8, tr_id, index, axi_tr_if_0(index));
    report "master_test_program: Writing data (3) to address (3)";

    -- By default it will run in Blocking mode
    execute_transaction(tr_id, index, axi_tr_if_0(index));

    -- Write data value 4 on byte lane 0 to address 4.
    create_write_transaction(4, tr_id, index, axi_tr_if_0(index));
    data_words(31 downto 0) := x"00000004";
    set_data_words(data_words, tr_id, index, axi_tr_if_0(index));
    set_write_strobes(1, tr_id, index, axi_tr_if_0(index));
    report "master_test_program: Writing data (4) to address (4)";

    -- By default it will run in Blocking mode
    execute_transaction(tr_id, index, axi_tr_if_0(index));

    --4 x Reads
    --Read data from address 1.
    create_read_transaction(1, tr_id, index, axi_tr_if_0(index));
    set_id(1, tr_id, index, axi_tr_if_0(index));
    set_size(AXI_BYTES_1, tr_id, index, axi_tr_if_0(index));
    execute_transaction(tr_id, index, axi_tr_if_0(index));

    get_data_words(data_words, tr_id, index, axi_tr_if_0(index));
    if(data_words(31 downto 0) = x"00000100") then
      report "master_test_program: Read correct data (1) at address (1)";
    else
     hwrite(lp, data_words(31 downto 0));
     report "master_test_program: Error: Expected data (1) at address 1,
but got " & lp.all;
    end if;

    --Read data from address 2.
    create_read_transaction(2, tr_id, index, axi_tr_if_0(index));
    set_id(2, tr_id, index, axi_tr_if_0(index));
    set_size(AXI_BYTES_1, tr_id, index, axi_tr_if_0(index));
    execute_transaction(tr_id, index, axi_tr_if_0(index));

    get_data_words(data_words, tr_id, index, axi_tr_if_0(index));
    if(data_words(31 downto 0) = x"00020000") then
      report "master_test_program: Read correct data (2) at address (2)";
    else
     hwrite(lp, data_words(31 downto 0));
     report "master_test_program: Error: Expected data (2) at address 2,
but got " & lp.all;
    end if;
```

```
    --Read data from address 3.
    create_read_transaction(3, tr_id, index, axi_tr_if_0(index));
    set_id(3, tr_id, index, axi_tr_if_0(index));
    set_size(AXI_BYTES_1, tr_id, index, axi_tr_if_0(index));
    execute_transaction(tr_id, index, axi_tr_if_0(index));

    get_data_words(data_words, tr_id, index, axi_tr_if_0(index));
    if(data_words(31 downto 0) = x"03000000") then
      report "master_test_program: Read correct data (3) at address (3)";
    else
     hwrite(lp, data_words(31 downto 0));
     report "master_test_program: Error: Expected data (3) at address 3,
but got " & lp.all;
    end if;

    --Read data from address 4.
    create_read_transaction(4, tr_id, index, axi_tr_if_0(index));
    set_id(4, tr_id, index, axi_tr_if_0(index));
    set_size(AXI_BYTES_1, tr_id, index, axi_tr_if_0(index));
    execute_transaction(tr_id, index, axi_tr_if_0(index));

    get_data_words(data_words, tr_id, index, axi_tr_if_0(index));
    if(data_words(31 downto 0) = x"00000004") then
      report "master_test_program: Read correct data (4) at address (4)";
    else
     hwrite(lp, data_words(31 downto 0));
     report "master_test_program: Error: Expected data (4) at address 4,
but got " & lp.all;
    end if;


    --  Write data burst length of 7 to start address 16.
    create_write_transaction(16, 7, tr_id, index, axi_tr_if_0(index));
    data_words(31 downto 0) := x"ACE0ACE1";
    set_data_words(data_words, 0, tr_id, index, axi_tr_if_0(index));
    data_words(31 downto 0) := x"ACE2ACE3";
    set_data_words(data_words, 1, tr_id, index, axi_tr_if_0(index));
    data_words(31 downto 0) := x"ACE4ACE5";
    set_data_words(data_words, 2, tr_id, index, axi_tr_if_0(index));
    data_words(31 downto 0) := x"ACE6ACE7";
    set_data_words(data_words, 3, tr_id, index, axi_tr_if_0(index));
    data_words(31 downto 0) := x"ACE8ACE9";
    set_data_words(data_words, 4, tr_id, index, axi_tr_if_0(index));
    data_words(31 downto 0) := x"ACEAACEB";
    set_data_words(data_words, 5, tr_id, index, axi_tr_if_0(index));
    data_words(31 downto 0) := x"ACECACED";
    set_data_words(data_words, 6, tr_id, index, axi_tr_if_0(index));
    data_words(31 downto 0) := x"ACEEACEF";
    set_data_words(data_words, 7, tr_id, index, axi_tr_if_0(index));
    for i in  0 to 7 loop
      set_write_strobes(15, i, tr_id, index, axi_tr_if_0(index));
    end loop;
    set_write_data_mode(AXI_DATA_WITH_ADDRESS, tr_id, index,
axi_tr_if_0(index));
    execute_transaction(tr_id, index, axi_tr_if_0(index));

    --  Write data burst length of 7 to start address 128  with LSB write
strobe inactive.
```

```
    create_write_transaction(128, 7, tr_id, index, axi_tr_if_0(index));
    data_words(31 downto 0) := x"ACE0ACE1";
    set_data_words(data_words, 0, tr_id, index, axi_tr_if_0(index));
    data_words(31 downto 0) := x"ACE2ACE3";
    set_data_words(data_words, 1, tr_id, index, axi_tr_if_0(index));
    data_words(31 downto 0) := x"ACE4ACE5";
    set_data_words(data_words, 2, tr_id, index, axi_tr_if_0(index));
    data_words(31 downto 0) := x"ACE6ACE7";
    set_data_words(data_words, 3, tr_id, index, axi_tr_if_0(index));
    data_words(31 downto 0) := x"ACE8ACE9";
    set_data_words(data_words, 4, tr_id, index, axi_tr_if_0(index));
    data_words(31 downto 0) := x"ACEAACEB";
    set_data_words(data_words, 5, tr_id, index, axi_tr_if_0(index));
    data_words(31 downto 0) := x"ACECACED";
    set_data_words(data_words, 6, tr_id, index, axi_tr_if_0(index));
    data_words(31 downto 0) := x"ACEEACEF";
    set_data_words(data_words, 7, tr_id, index, axi_tr_if_0(index));
    set_write_strobes(14, 0, tr_id, index, axi_tr_if_0(index));
    for i in  1 to 7 loop
      set_write_strobes(15, i, tr_id, index, axi_tr_if_0(index));
    end loop;
    execute_transaction(tr_id, index, axi_tr_if_0(index));

    -- Read data burst of length 1 from address 16.
    create_read_transaction(16, 1, tr_id, index, axi_tr_if_0(index));
    execute_transaction(tr_id, index, axi_tr_if_0(index));

    get_data_words(data_words, 0, tr_id, index, axi_tr_if_0(index));
    if(data_words(31 downto 0) = x"ACE0ACE1") then
      report "master_test_program: Read correct data (hACE0ACE1) at
address (16)";
    else
     hwrite(lp, data_words(31 downto 0));
     report "master_test_program: Error: Expected data (hACE0ACE1) at
address (16), but got " & lp.all;
    end if;
    get_data_words(data_words, 1, tr_id, index, axi_tr_if_0(index));
    if(data_words(31 downto 0) = x"ACE2ACE3") then
      report "master_test_program: Read correct data (hACE2ACE3) at
address (20)";
    else
      hwrite(lp, data_words(31 downto 0));
      report "master_test_program: Error: Expected data (hACE2ACE3) at
address (20), but got " & lp.all;
    end if;

    -- Read data burst of length 1 from address 128.
    create_read_transaction(128, 1, tr_id, index, axi_tr_if_0(index));
    execute_transaction(tr_id, index, axi_tr_if_0(index));

    get_data_words(data_words, 0, tr_id, index, axi_tr_if_0(index));
    if(data_words(31 downto 0) = x"ACE0AC00") then
     report "master_test_program: Read correct data (ACE0AC00) at address
(128)";
    else
      hwrite(lp, data_words(31 downto 0));
     report "master_test_program: Error: Expected data (ACE0AC00) at
address (128), but got " & lp.all;
```

```
    end if;
    get_data_words(data_words, 1, tr_id, index, axi_tr_if_0(index));
    if(data_words(31 downto 0) = x"ACE2ACE3") then
      report "master_test_program: Read correct data (hACE2ACE3) at
address (132)";
    else
      hwrite(lp, data_words(31 downto 0));
      report "master_test_program: Error: Expected data (hACE2ACE3) at
address (132), but got " & lp.all;
    end if;

    wait;
  end process;
end master_test_program_a;
```

# VHDL AXI4 Slave BFM Test Program

The following code example contains a simple AXI4 slave test program that shows the slave BFM API being used to communicate with a master and create stimulus. This test program is discussed further in the VHDL Tutorials Chapter.

```
-- ****************************************************************************
--
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THE PROPERTY OF
-- MENTOR GRAPHICS CORPORATION OR ITS LICENSORS AND IS SUBJECT TO LICENSE
TERMS.
--
-- ****************************************************************************
--
-- This is a simple example of an AXI Slave to demonstrate the
mgc_axi4_slave BFM usage.
--
-- This is a fairly generic slave which handles almost all write and read
transaction
-- scenarios from master. It handles write data with address as well as
data after address
-- both.
--
-- This slave code is divided in two parts, one which user might need to
edit to change slave
-- mode (Transaction/burst or Phase level) and memory handling.
-- Out of the code which is grouped as user do not need to edit, could be
edited for achieving
-- required phase valid/ready delays.
--
library ieee ;
use ieee.std_logic_1164.all;
use ieee.std_logic_arith.all;

library work;
```

```
use work.all;
use work.mgc_axi4_bfm_pkg.all;
use std.textio.all;
use ieee.std_logic_textio.all;

entity slave_test_program is
   generic (AXI4_ADDRESS_WIDTH : integer := 32;
          AXI4_RDATA_WIDTH : integer := 32;
          AXI4_WDATA_WIDTH : integer := 32;
          AXI4_ID_WIDTH    : integer := 4;
          AXI4_USER_WIDTH : integer := 4;
          AXI4_REGION_MAP_SIZE : integer := 16;
           index : integer range 0 to 511 :=0
          );
 end slave_test_program;

architecture slave_test_program_a of slave_test_program is
  type axi4_slave_mode_e is (AXI4_TRANSACTION_SLAVE, AXI4_PHASE_SLAVE);
  type memory_t is array (0 to 2**16-1) of std_logic_vector(7 downto 0);

  --////////////////////////////////////////////////
  -- Code user could edit according to requirements
  --////////////////////////////////////////////////

  -- Variable : m_wr_addr_phase_ready_delay
  signal m_wr_addr_phase_ready_delay : integer := 2;

  -- Variable : m_rd_addr_phase_ready_delay
  signal m_rd_addr_phase_ready_delay : integer := 2;

  -- Variable : m_wr_data_phase_ready_delay
  signal m_wr_data_phase_ready_delay : integer := 2;

  -- Slave mode seclection : default it is transaction level slave
  signal slave_mode : axi4_slave_mode_e := AXI4_TRANSACTION_SLAVE;

  -- Storage for a memory
  shared variable mem : memory_t;

  procedure do_byte_read(addr : in std_logic_vector(AXI4_MAX_BIT_SIZE-1
downto 0); data : out std_logic_vector(7 downto 0));
  procedure do_byte_write(addr : in std_logic_vector(AXI4_MAX_BIT_SIZE-1
downto 0);  data : in std_logic_vector(7 downto 0));
  procedure set_wr_resp_valid_delay(id : integer; signal tr_if : inout
axi4_vhd_if_struct_t);
  procedure set_wr_resp_valid_delay(id : integer; path_id : in
axi4_path_t; signal tr_if : inout axi4_vhd_if_struct_t);
  procedure set_read_data_valid_delay(id : integer; signal tr_if : inout
axi4_vhd_if_struct_t);
  procedure set_read_data_valid_delay(id : integer; path_id : in
axi4_path_t; signal tr_if : inout axi4_vhd_if_struct_t);

  -- Procedure : do_byte_read
  -- Procedure to provide read data byte from memory at particular input
  -- address
  procedure do_byte_read(addr : in std_logic_vector(AXI4_MAX_BIT_SIZE-1
downto 0); data : out std_logic_vector(7 downto 0)) is
  begin
```

```
    data := mem(to_integer(addr));
  end do_byte_read;

  -- Procedure : do_byte_write
  -- Procedure to write data byte to memory at particular input address
  procedure do_byte_write(addr : in std_logic_vector(AXI4_MAX_BIT_SIZE-1
downto 0);  data : in std_logic_vector(7 downto 0)) is
  begin
    mem(to_integer(addr)) := data;
  end do_byte_write;

  -- Procedure : set_wr_resp_valid_delay
  -- This is used to set write response phase valid delay to start driving
  -- write response phase after specified delay.
  procedure set_wr_resp_valid_delay(id : integer; signal tr_if : inout
axi4_vhd_if_struct_t) is
  begin
    set_write_response_valid_delay(2, id, index, tr_if);
  end set_wr_resp_valid_delay;
  procedure set_wr_resp_valid_delay(id : integer; path_id : in
axi4_path_t; signal tr_if : inout axi4_vhd_if_struct_t) is
  begin
    set_write_response_valid_delay(2, id, index, path_id, tr_if);
  end set_wr_resp_valid_delay;

  -- Procedure : set_read_data_valid_delay
  -- This will set the ready delays for each write data phase in a write
data
  -- burst
  procedure set_read_data_valid_delay(id : integer; signal tr_if : inout
axi4_vhd_if_struct_t) is
    variable burst_length : integer;
  begin
    get_burst_length(burst_length, id, index, tr_if);
    for i in  0 to burst_length loop
      set_data_valid_delay(i, i, id, index, tr_if);
    end loop;
  end set_read_data_valid_delay;
  procedure set_read_data_valid_delay(id : integer; path_id : in
axi4_path_t; signal tr_if : inout axi4_vhd_if_struct_t) is
    variable burst_length : integer;
  begin
    get_burst_length(burst_length, id, index, path_id, tr_if);
    for i in  0 to burst_length loop
      set_data_valid_delay(i, i, id, index, path_id, tr_if);
    end loop;
  end set_read_data_valid_delay;

begin

  -- To create pipelining in VHDL there are multiple channel path in each
API.
  -- So each process will choose separate path to interact with BFM.

  -- process_write : write address phase through path 0
  -- This process keep receiving write address phase and push the
transaction into queue through
  -- push_transaction_id API.
```

```
  process
    variable write_trans : integer;
  begin
    wait_on(AXI4_RESET_0_TO_1, index, axi4_tr_if_0(index));
    wait_on(AXI4_CLOCK_POSEDGE, index, axi4_tr_if_0(index));
    loop
      create_slave_transaction(write_trans, index, axi4_tr_if_0(index));
      get_write_addr_phase(write_trans, index, axi4_tr_if_0(index));
      push_transaction_id(write_trans, AXI4_QUEUE_ID_0, index,
axi4_tr_if_0(index));
    end loop;
    wait;
  end process;

  -- handle_write : write data phase through path 1
  -- This method receive write data burst or phases for write transaction
  -- depending upon slave working mode and write data to memory.
  process
    variable write_trans: integer;
    variable byte_length : integer;
    variable burst_length : integer;
    variable addr : std_logic_vector(AXI4_MAX_BIT_SIZE-1 downto 0);
    variable data : std_logic_vector(7 downto 0);
    variable last : integer := 0;
    variable loop_i : integer := 0;
  begin
    loop
     pop_transaction_id(write_trans, AXI4_QUEUE_ID_0, index, AXI4_PATH_1,
axi4_tr_if_1(index));

      if (slave_mode = AXI4_TRANSACTION_SLAVE) then
        get_write_data_burst(write_trans, index, AXI4_PATH_1,
axi4_tr_if_1(index));
        get_burst_length(burst_length, write_trans, index, AXI4_PATH_1,
axi4_tr_if_1(index));
        for i in  0 to burst_length loop
         get_write_addr_data(write_trans,  i, 0, byte_length, addr, data,
index, AXI4_PATH_1, axi4_tr_if_1(index));
          do_byte_write(addr, data);
          if byte_length > 1 then
            for j in 1 to byte_length-1 loop
               get_write_addr_data(write_trans,  i, j, byte_length, addr,
data, index, AXI4_PATH_1, axi4_tr_if_1(index));
                do_byte_write(addr, data);
            end loop;
          end if;
        end loop;
      else
        last := 0;
        loop_i := 0;
        while(last = 0) loop
          get_write_data_phase(write_trans, loop_i, last, index,
AXI4_PATH_1, axi4_tr_if_1(index));
         get_write_addr_data(write_trans,  loop_i, 0, byte_length, addr,
data, index, AXI4_PATH_1, axi4_tr_if_1(index));
          do_byte_write(addr, data);
          if byte_length > 1 then
            for j in 1 to byte_length-1 loop
```

```
              get_write_addr_data(write_trans,  loop_i, j, byte_length,
addr, data, index, AXI4_PATH_1, axi4_tr_if_1(index));
              do_byte_write(addr, data);
            end loop;
          end if;
          loop_i := loop_i + 1;
        end loop;
      end if;
      push_transaction_id(write_trans, AXI4_QUEUE_ID_2, index,
AXI4_PATH_1, axi4_tr_if_1(index));
    end loop;
    wait;
  end process;

  -- handle_response : write response phase through path 2
  -- This method sends the write response phase
  process
    variable write_trans: integer;
  begin
    loop
     pop_transaction_id(write_trans, AXI4_QUEUE_ID_2, index, AXI4_PATH_2,
axi4_tr_if_2(index));
      set_wr_resp_valid_delay(write_trans, AXI4_PATH_2,
axi4_tr_if_2(index));
      execute_write_response_phase(write_trans, index, AXI4_PATH_2,
axi4_tr_if_2(index));
    end loop;
    wait;
  end process;

  -- process_read : read address phase through path 3
  -- This process keep receiving read address phase and push the
transaction into queue through
  -- push_transaction_id API.
  process
    variable read_trans: integer;
  begin
    wait_on(AXI4_RESET_0_TO_1, index, AXI4_PATH_3, axi4_tr_if_3(index));
    wait_on(AXI4_CLOCK_POSEDGE, index, AXI4_PATH_3, axi4_tr_if_3(index));
    loop
      create_slave_transaction(read_trans, index, AXI4_PATH_3,
axi4_tr_if_3(index));
      get_read_addr_phase(read_trans, index, AXI4_PATH_3,
axi4_tr_if_3(index));
     push_transaction_id(read_trans, AXI4_QUEUE_ID_1, index, AXI4_PATH_3,
axi4_tr_if_3(index));
    end loop;
    wait;
  end process;

  -- handle_read : read data and response through path 4
  -- This process reads data from memory and send read data/response
either at
  -- burst or phase level depending upon slave working mode.
  process
    variable read_trans: integer;
    variable burst_length : integer;
    variable byte_length : integer;
```

```
    variable addr : std_logic_vector(AXI4_MAX_BIT_SIZE-1 downto 0);
    variable data : std_logic_vector(7 downto 0);
  begin
    loop
      pop_transaction_id(read_trans, AXI4_QUEUE_ID_1, index, AXI4_PATH_4,
axi4_tr_if_4(index));
      set_read_data_valid_delay(read_trans, AXI4_PATH_4,
axi4_tr_if_4(index));

      get_burst_length(burst_length, read_trans, index, AXI4_PATH_4,
axi4_tr_if_4(index));
      for i in  0 to burst_length loop
        get_read_addr(read_trans,  i, 0, byte_length, addr, index,
AXI4_PATH_4, axi4_tr_if_4(index));
        do_byte_read(addr, data);
        set_read_data(read_trans, i, 0, byte_length, addr, data, index,
AXI4_PATH_4, axi4_tr_if_4(index));
        if byte_length > 1 then
          for j in 1 to byte_length-1 loop
            get_read_addr(read_trans,  i, j, byte_length, addr, index,
AXI4_PATH_4, axi4_tr_if_4(index));
            do_byte_read(addr, data);
            set_read_data(read_trans, i, j, byte_length, addr, data,
index, AXI4_PATH_4, axi4_tr_if_4(index));
          end loop;
        end if;
        if slave_mode = AXI4_PHASE_SLAVE then
          execute_read_data_phase(read_trans, i, index, AXI4_PATH_4,
axi4_tr_if_4(index));
        end if;
      end loop;
      if slave_mode = AXI4_TRANSACTION_SLAVE then
        execute_read_data_burst(read_trans, index, AXI4_PATH_4,
axi4_tr_if_4(index));
      end if;
    end loop;
    wait;
  end process;

  -- handle_write_addr_ready : write address ready through path 5
  -- This method assert/de-assert the write address channel ready signal.
  -- Assertion and de-assertion is done based on
m_wr_addr_phase_ready_delay
  process
    variable tmp_ready_delay : integer;
  begin
    wait_on(AXI4_RESET_0_TO_1, index, AXI4_PATH_5, axi4_tr_if_5(index));
    wait_on(AXI4_CLOCK_POSEDGE, index, AXI4_PATH_5, axi4_tr_if_5(index));
    loop
      wait until m_wr_addr_phase_ready_delay > 0;
      tmp_ready_delay := m_wr_addr_phase_ready_delay;
      execute_write_addr_ready(0, 1, index, AXI4_PATH_5,
axi4_tr_if_5(index));
      get_write_addr_cycle(index, AXI4_PATH_5, axi4_tr_if_5(index));
      if(tmp_ready_delay > 1) then
        for i in  0 to tmp_ready_delay-2 loop
          wait_on(AXI4_CLOCK_POSEDGE, index, AXI4_PATH_5,
axi4_tr_if_5(index));
```

```
        end loop;
      end if;
      execute_write_addr_ready(1, 1, index, AXI4_PATH_5,
axi4_tr_if_5(index));
    end loop;
    wait;
  end process;

  -- handle_read_addr_ready : read address ready through path 6
  -- This method assert/de-assert the write address channel ready signal.
  -- Assertion and de-assertion is done based on
m_rd_addr_phase_ready_delay
  process
    variable tmp_ready_delay : integer;
  begin
    wait_on(AXI4_RESET_0_TO_1, index, AXI4_PATH_6, axi4_tr_if_6(index));
    wait_on(AXI4_CLOCK_POSEDGE, index, AXI4_PATH_6, axi4_tr_if_6(index));
    loop
      wait until m_rd_addr_phase_ready_delay > 0;
      tmp_ready_delay := m_rd_addr_phase_ready_delay;
      execute_read_addr_ready(0, 1, index, AXI4_PATH_6,
axi4_tr_if_6(index));
      get_read_addr_cycle(index, AXI4_PATH_6, axi4_tr_if_6(index));
      if(tmp_ready_delay > 1) then
        for i in  0 to tmp_ready_delay-2 loop
          wait_on(AXI4_CLOCK_POSEDGE, index, AXI4_PATH_6,
axi4_tr_if_6(index));
        end loop;
      end if;
      execute_read_addr_ready(1, 1, index, AXI4_PATH_6,
axi4_tr_if_6(index));
    end loop;
    wait;
  end process;

  -- handle_write_data_ready : write data ready through path 7
  -- This method assert/de-assert the write data channel ready signal.
  -- Assertion and de-assertion is done based on
m_wr_data_phase_ready_delay
  process
    variable tmp_ready_delay : integer;
  begin
    wait_on(AXI4_RESET_0_TO_1, index, AXI4_PATH_7, axi4_tr_if_7(index));
    wait_on(AXI4_CLOCK_POSEDGE, index, AXI4_PATH_7, axi4_tr_if_7(index));
    loop
      wait until m_wr_data_phase_ready_delay > 0;
      tmp_ready_delay := m_wr_data_phase_ready_delay;
      execute_write_data_ready(0, 1, index, AXI4_PATH_7,
axi4_tr_if_7(index));
      get_write_data_cycle(index, AXI4_PATH_7, axi4_tr_if_7(index));
      if(tmp_ready_delay > 1) then
        for i in  0 to tmp_ready_delay-2 loop
          wait_on(AXI4_CLOCK_POSEDGE, index, AXI4_PATH_7,
axi4_tr_if_7(index));
        end loop;
      end if;
      execute_write_data_ready(1, 1, index, AXI4_PATH_7,
axi4_tr_if_7(index));
```

```
        end loop;
        wait;
      end process;

    end slave_test_program_a;
```

# Third-party Software for Mentor Verification IP Altera Edition

This section provides information on open source and third-party software that may be included in the Mentor Verification IP Altera Edition software product.

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# End-User License Agreement

The latest version of the End-User License Agreement is available on-line at:
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## END-USER LICENSE AGREEMENT ("Agreement")

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